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MACHINE FOR SWEEPING AND SPRINKLING STREETS.

THIS new machine, recently adopted by the municipality of Valentia, Spain, is designed for the simultaneous sprinkling and sweeping of the public streets. The sweeping machines hitherto employed all do their work imperfectly, on account of the defective method adopted for constructing the brush. Besides, before they can be used, the street must be sprinkled by men or by a sprinkler drawn by a horse. This system, which requires a double labor, is evidently very expensive.

In order to obviate such inconveniences, Mr. Orduna has improved the street sweeper now employed by totally changing the construction of the brush, and adding a reservoir of water and sprinkling pipes to the machine, so that the latter, drawn by one horse and operated by one man, serves for sprinkling and sweeping the streets simultaneously.

The machine consists of a one horse cart whose wheels, provided with clicks, B, actuate the ratchets, A, and consequently the axle and the bevel wheel, C. This latter transmits motion to the pinion, D, the shaft, E, and the pulley and nut, F, which, through a pitch chain, H, and a second pulley and nut, K, revolves the brush. In order to stop the rotary motion, it is only necessary to free the clicks, B.

In addition to the mechanism for revolving the brush, the machine is provided with a second mechanism, which is placed upon the frame, and consists of a screw and winch, M, by means of which the driver raises and lowers the jointed fork, N O, which is connected with a lever belonging to the shaft, P. This latter, when revolved, raises or lowers the brush through the intermedium of the connecting rods, R.

This brush is of peculiar structure. It consists of a wooden axle, L, of square section, with iron ferrules and pivots. To the four sides of this axle, through iron bands and screws, are fastened bunches of piassara, couch grass, rush, or other suitable material. The engravings sufficiently well show the arrangement of this brush, which has the advantage over its predecessors of being cheap and easily mounted, and of permitting the worn out whisks to be readily replaced by new ones.

To permit of sprinkling being done at the same time as sweeping, the machine carries an iron plate reservoir, S, which is filled through the apertures, J, which are provided with covers. From the bottom of this reservoir starts a pipe, T, provided with a cock, V, and dividing into three branches to lead the water to the sprinkling pipe, X, which is placed at right angles with the shafts and is furnished with small apertures beneath throughout its entire length. The water issues in a shower from these apertures, and sprinkles the ground before the passage of the brush.

By means of this combination, the sweeping and sprinkling can be effected simultaneously or separately, and a notable saving be obtained in the operation of cleaning the public thoroughfares, and, at the same time, a reduction in the cost price of the *materiel*.—*Annales Industrielles.*

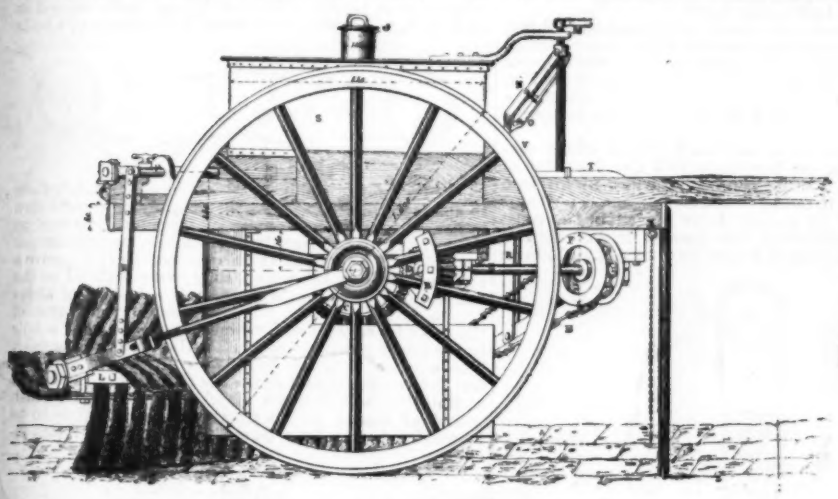


FIG. 1.—SIDE VIEW (Scale, 1-10).

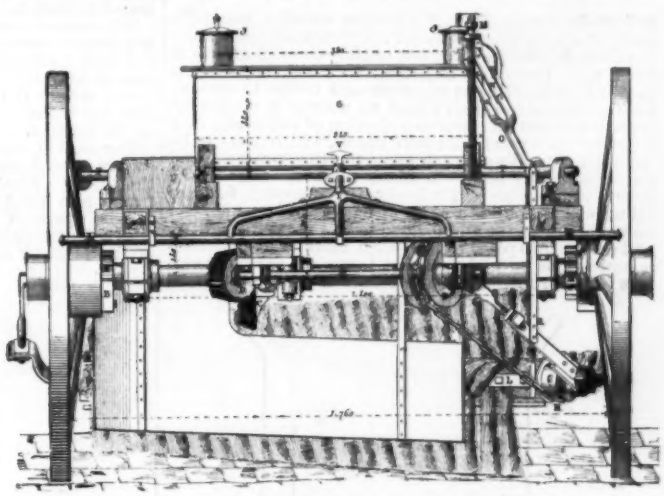


FIG. 3.—FRONT VIEW (Scale, 1-10).

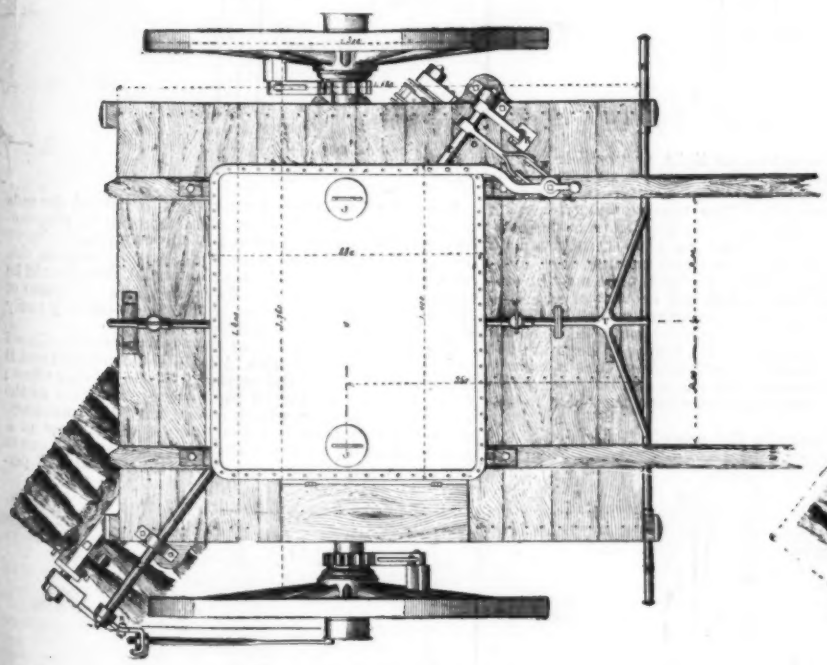


FIG. 2.—PLAN VIEW (Scale, 1-10).

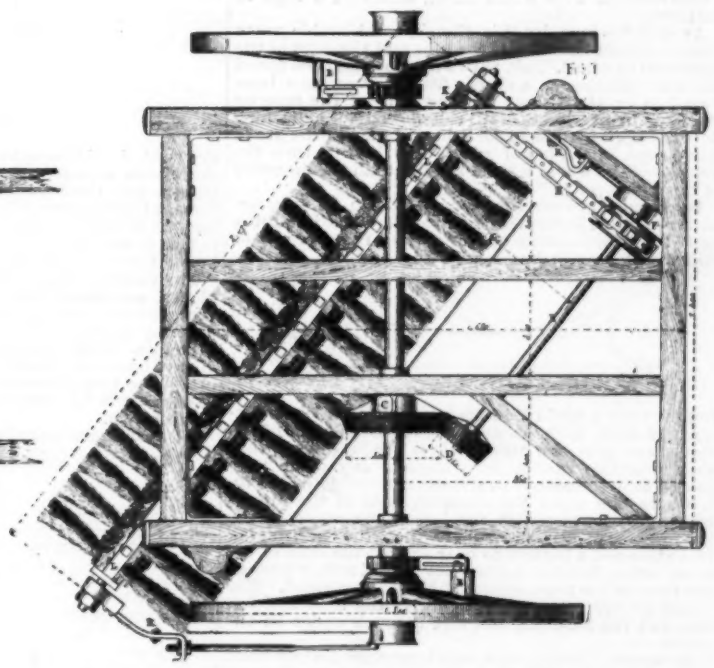


FIG. 4.—PLAN VIEW OF THE MECHANISM (Scale, 1-10).

LEPROSY is said to be afflicting many Scandinavian immigrants in northern Minnesota and Dakota. It is brought from the old country, and seems to spread but little here.

TRANSMISSION OF POWER BY ROPE.

THE subject of rope transmission of power is one that is claiming attention among electric light men, especially those interested in large stations. The Chicago Arc Light and Power Company is now running one of these systems, and your correspondent is informed that they are well pleased with its operation.

The transmission of power by wire or hemp rope is in the use of an endless rope running at great speed over a grooved wheel, in place of a leather belt running over a flat-faced pulley. This above method of transmitting power over long distances is by no means a new one, though in practice it may be said that it is comparatively new, as its adoption has been of such slow progress as to occupy but little room in the everyday practice of millwrights and engineers.

The principle, however, is rapidly gaining favor, and the future for the transmission of power by rope may be pronounced very broad. Its application ranges anywhere from twenty feet up to over three miles, and in point of first cost cannot be approached by any other method, as will be seen later. The method dates back to the year 1850, and is in extensive use all over Europe, but it has in this country but recently come into general use. The variety of methods for applying the use of ropes in transmitting power are too many to enable us to describe all. A few of the principal points, however, will suffice to enable the user to observe the necessary points in its successful manipulation.

In places that are sheltered from the weather, hemp or cotton rope will answer for all purposes, but in transmitting power from one building to another it will be necessary to use wire rope with a hemp core. For

each of these purposes a different kind of pulley or wheel will be required. In the case of the wire rope it is necessary to line the yoke or tread of the wheel with some soft substance to prevent abrasion and slipping, which would very soon result in the entire wearing out of the rope. For this purpose several substances have been used, chief among them being wood, leather, and rubber. In order that these or any other material for that purpose can be easily secured to the wheel, it is necessary that the tread of the wheel shall be cast in the shape of an inverted wedge, as shown in Fig. 1; the pieces of wood are then cut to fit this cavity

Fig. 1

and are let into it through a square opening, generally made at a point on its edge for that purpose. Each piece is driven in after its neighbor until the entire groove is filled up. The chief objection to wood, however, is that it is susceptible to moisture and liable to fly out. Leather filling has been found to answer a good purpose, but it has the serious objection of requiring, on a large wheel, several thousand pieces, which have to be stamped out with a punch made for that purpose, and requiring many hours to place them on edge in the groove of the wheel. Probably the cheapest form of filling will be found in strips of hard rubber, which can be made in lengths and formed to fit the cavity tightly, and driven into place by a wooden hammer. The rubber is impervious to moisture and forms an excellent surface for the rope. Fig. 1 represents a cross section of

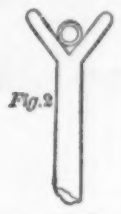


Fig. 2

Fig. 3

a sheave fitted with a soft filling and with a rope in position.

As will be seen by this sketch, considerable room exists between the sides of the rope and the sides of the flange of the wheel. This, with wire rope, has been found the best practice, as a closely fitting groove has been found to greatly reduce the longevity of the rope by the consequent friction of the sides in contact, and which does not appear to be of such importance in the use of hemp rope, in the use of which it is best to turn the grooves of the wheel a trifle smaller than the diameter of the new rope.

Many mistakes are sometimes made in this matter, and the system is frequently blamed for what is nothing more than carelessness on the part of the designer or millwright, as will be seen in Fig. 2, which shows a

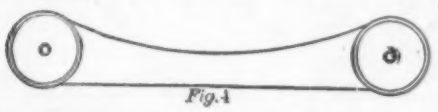


Fig. 4

pulley with a plain V in its periphery, which is frequently done without any regard to the size of the rope that is to run over it. It is needless to say that such practices cannot help matters any. The rope should fit in the groove in a manner represented in Fig. 3, where one third the circumference of the rope is brought in contact with the face of the groove. It is the practice of some to square the grooves, bringing two sides and a bottom to bear against the sides of the rope, but as this has a tendency to ultimately change the form of the rope, it cannot be recommended. The round groove will be found to give the most satisfaction and the least trouble, and is much easier on the splice.

In transmitting by rope, one important feature must be observed, and that is an arrangement for taking up

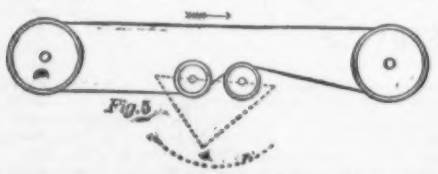


Fig. 5

the slack, which will be found to be considerable with hemp or cotton. In cases where no great distance is to be traversed, and there is plenty of head room, probably no provision may be found necessary, in which case the slack side can be run on top, as shown in Fig. 4. As it is necessary in this method to use as large pulleys as possible, the larger the better, the distance between the top and bottom of the pulleys will be found to be sufficient after the slack has been taken out of the rope. It will, however, be found good practice, whether there be a tension wheel or not on the system, to take the slack out of new rope before splicing, as there is so much give to a long length that unless the tension wheel has considerable travel the rope will require taking up before running long, which with a long splice is not always convenient. The easiest method of taking out the slack is to run the rope one or more times, according to its length, between two points, and hang a weight in the center, and allow it to remain there as long as possible, and occasionally applying a little weight with the hands. Another way of accomplishing the same result is to bend the rope around the wheels it is to run on and twine the ends together and apply the weight. This, however, cannot always be done, as the wheels may be in motion. Either way, however,

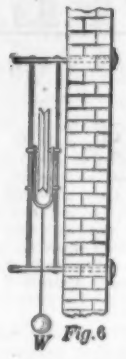


Fig. 6

will answer the purpose, and the remaining slack can then be cared for by tension wheel.

Where there is a run of seventy-five or a hundred feet it will be necessary to use a tension wheel of some kind. For such a purpose and for a single line the most simple form in the practice we have known is shown in Fig. 5, and where the head room will not permit of the pull side being down, the tension wheels can be placed on the bottom.

The sketch represents two small wheels whose diameters should not be less than half the diameter of the driver. The wheels should be swung in an iron frame, and hung to swing round each other. The frame can be operated by a short lever placed in the most convenient position, and a light tension kept on the end of the lever by means of a cast iron weight. Of course

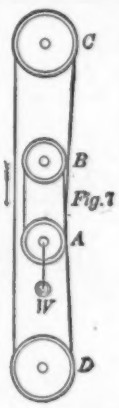


Fig. 7

the rope should be put on as tight as possible before the wheels are allowed to bear upon it, as it is advantageous that the rope should have as little turn around these wheels as possible. The tension wheels can be hung in a light wooden frame suspended from the ceiling, or if the pulleys be close to a wall, they can be bolted through the brickwork to advantage.

The various forms of tension wheels that may be employed are many, and it will not be out of place to enumerate a few of the most important, which although differing in structure are an embodiment of the same principle. As we have explained, tension wheels are not always necessary, though it will be seen that in nearly every case they are essential; there are, however, some cases, as will be seen later on, where they can be dispensed with.

All that is necessary in the use of the tension wheel

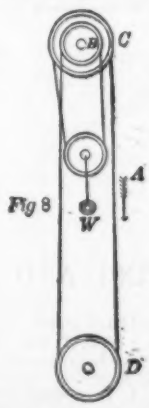


Fig 8

is to merely take up and pay out the amount of elongation in the rope, consequent upon expansion and contraction by different degrees of moisture and the variation by the load, therefore any excess of pressure above this amount will bring an unnecessary strain upon the rope, and decrease its length of life. In cases where the power is to be transmitted vertically, it will be found that very little will be required above the weight of the tension wheel and frame, and more especially where the power to be transmitted is light and steady. Fig. 6 is a favorite form of tension wheel and frame used in case of vertical arrangement, and is shown bolted to a brick wall; in this instance it was required to transmit ten horse power, from the basement of a building up to the third floor, and this tension wheel was placed on the wall of the first floor, the ends of the shafts being extended to reach the wall of the building, the ropes passing up through the benches of the workmen. On each floor, holes were cut through the floors and benches and two inch ferrules were fitted in, through which the rope passed. At the benches the ferrules were extended up about a foot, to prevent the workmen from throwing tools, etc., against the rope.

The wheels on the driving and driven shafts were two feet in diameter, and made 190 turns per minute; the

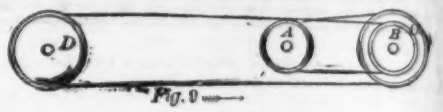


Fig. 9

rope used was one inch in diameter, and was laid over with a long splice 6 feet in length—3 strands. About two feet of stretch was taken out of the rope before splicing, which brought the top of the tension wheel close up to the top of the frame. At the expiration of a week the elongation of the rope brought the position of the tension wheel about central in the frame, as shown in the sketch, where it now runs, smoothly and noiselessly. After the rope was spliced and ready to run, it was slightly greased with tallow, or, better, painted with boiled oil and mineral paint, to allay the absorption of moisture.

The method of construction of the tension frame in question was as follows: The wheel was fitted to a yoke of 2 × ½" bar iron and ⅝" eye bolts tapped in each side, of which there were four; these eye bolts

Fig. 10

were bored for ⅞ rod iron, which passed through them to act as guides. Two lengths of ⅞" rod iron were then taken, about six feet long, and securely riveted at their ends into two lengths of the same iron that formed the yoke. The ends of these were reduced to receive a nut and washer, by which they were secured to the outside of the wall. W represents a weight of about fifteen pounds, which was attached to the bottom of the yoke by a small rod, which passed through a hole in the lower wall piece and below the center of the yoke. The eye bolts in the yoke were drilled to allow the frame to move up and down the rods freely. The cost of the job, including the wheel, was about $12, which would of course be no greater if the distance to be transmitted was four times what it was in this instance.

FIG. 11.

In cases where it is not convenient to extend the ends of the shafting to the walls, the frame can be suspended from the ceiling, in an out of the way place or down by the side of a post, with the same results as in this case. In arranging the tension wheel, care should be taken that the rope leads off directly from the center of the wheel, as at high speed it will jump off very easily if allowed to swing from side to side.

Fig. 7 is an elevation of the arrangement, reduced between centers, in which A is the tension wheel and B is the idler, C is the driven and D is the driving wheel; idler, B, must be bolted to the wall the same as the frame of the tension wheel, except that it is stationary, while the centers of D must pass between those of A and B, in order to allow the rope to pass from one to the other. As will be seen, this arrangement will per-

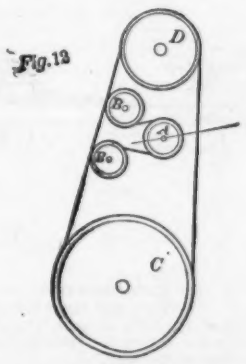


Fig. 12

mit of an extension vertically to an almost indefinite length, the only necessary change being in a slight increase in the diameter of the pulleys, and a corresponding increase in the weight W to counteract the weight of the rope and bring it to bear against the face of the lower wheel, which, however, is very slight.

Another method of arriving at the same results as above described is shown in Fig. 8, in which D is the driver, C the driven, B the idler, and A the tension wheel. In this arrangement it will be noticed that the idler is bored out to run on the driven shaft, the inside hubs of the wheels, B and C, are turned off to a face, the wheel, C, is keyed or set-screwed to the shaft, and

the idler, B, is kept up to it by a collar, the shaft forming a journal. The tension wheel, A, will perform the same office as in Fig. 7, with the exception that it will be found necessary to permit of a greater distance between it and the idler, as the distance between the centers will be greater in this instance than in the one previously described. As will be noticed, the center of the tension wheel is directly under that of the idler. This is not absolutely necessary, as the opposite sides will have to correspond with the opposite sides of wheels B and C.

The question of lubricating wheel B will be found to be a matter of little importance, as the shaft is traveling in the same direction as the wheel itself, and the number of revolutions is therefore only what the difference between the diameter of the two wheels may be. In fact, as the only point for using smaller wheels for idlers and tension is the cost in price, there is no objection to the wheels being the same diameter all round, in which case the two wheels B and C can be both keyed to the shaft, and no lubrication required except for the tension wheel.

Fig. 9 is the same method employed horizontally from one shaft to another, either in the same building or from one building to another, across an alley or otherwise. In this case tension wheel, A, can be suspended from the ceiling or joists, and the tension kept upon it by means of a larger weight over a small pulley. The size of the weight in this instance will have to be much greater than in the cases explained above, as the weight itself is all the tension there is on the rope. In cases of this kind it is the practice of some to make the tension wheels stationary in the guides, and to take up the slack by means of a screw. This, however, cannot be recommended, as the difference in tension must then be taken out of the rope, which consequently suffers, and it is no cheaper, as the cost of the screw and attachments will be found to more than balance the cost of the weight and wheel over which it runs. In this case it is also optional as to whether the size of the idler is as great as that of the driven wheel.

We would prefer to make the idler loose on the shaft, as it will be seen that tightening it on the shaft practically places the arrangement on the same basis as that of two belts running over the same pulley. It is generally accepted that one belt will do more work than the other, no matter how favorable the conditions or how true the pulleys. Experiments made by us in this direction have led us to conclude that running or driving the same shaft by two belts is bad business, and ought never to be encouraged. This knowledge therefore forces one to conclude that wheel B should be loose on the shaft.

There are many instances where it is necessary to transmit power long distances. For instance, a factory is situated a mile or so from a head of water or running stream, or to transmit steam power from one building to another, across a railroad or river, or other people's property. The use of shafting in either of these cases, although practicable, would incur enormous expense, so much so in fact as to make many cases an unprofitable investment, if not impossible. In all of these cases rope transmission comes to the rescue, both in point of economy and in application. In either of these cases, however, where the distance is not over 250 or 300 feet, it will be necessary to erect what is called intermediate stations, and in the use of wire rope these stations may be placed as far as 400 feet apart, where there is sufficient head room to permit of the sag of rope.

As it is only possible, as previously explained, to run wire rope in cases where it is exposed to the action of the weather, we will confine our remarks to it and the use of the wheel illustrated in Fig. 1.

Wire rope is as pliable as hemp rope of the same strength, and will therefore run over the same sized wheels as the latter, though it is of special advantage to either to use wheels with as large a diameter as possible, though there is a limit to this, as the wear increases with the velocity, and it may even be found better to increase the load rather than increase the velocity.

Wire rope is made either with a wire or hemp center. The latter is more pliable than the former, and will permit of the use of smaller pulleys, and will wear better where there are short bends to be made. Where a certain amount of power is to be transmitted, say 800 feet, and there is plenty of room to permit of the sag of the rope, it will be necessary to erect at least one intermediate station, which can be erected either of wood or masonry, according to circumstances; where, however, there is not sufficient room to allow of the sag of the rope, it will be necessary to take the weight of the rope upon idler wheels, the diameter of which should not be less than a third of the diameter of the driver, more especially at a high rate of speed. Where the distances between centers, however, is short, much smaller idlers may be used with good results, though a limit will be found in a quarter the diameter of the driver.

Fig. 10 shows an arrangement above referred to, in which case A and C are the driver and driven wheels, and B the intermediate station, which consists of two wheels mounted upon one shaft and keyed thereto, as represented in Fig. 11. In this case it will be found good practice to make the idlers as large as the working pulleys, as they both have to perform the same amount of work as the others. Where there is a limited amount of head room, station B can be raised much higher than either of the other points, which may be found good practice. Where wire rope is used, it will be found necessary to use a lubricant of some kind, in which case probably the best and cheapest is a mixture of tar and linseed oil, the consistency of which should vary with the seasons. In other words, more tar and less oil in summer and the reverse in winter, as tar alone will be found to be too thick in cold weather.

Galvanized wire rope cannot be recommended for the transmission of power, as the friction would soon remove the coating and the process of oxidation would go on faster than ever; steel wire rope can be recommended, however, for this purpose, not so much, however, for its tensile strength, as it is not much above iron, but for its wearing qualities, the duration of which is much beyond that of iron wire rope.

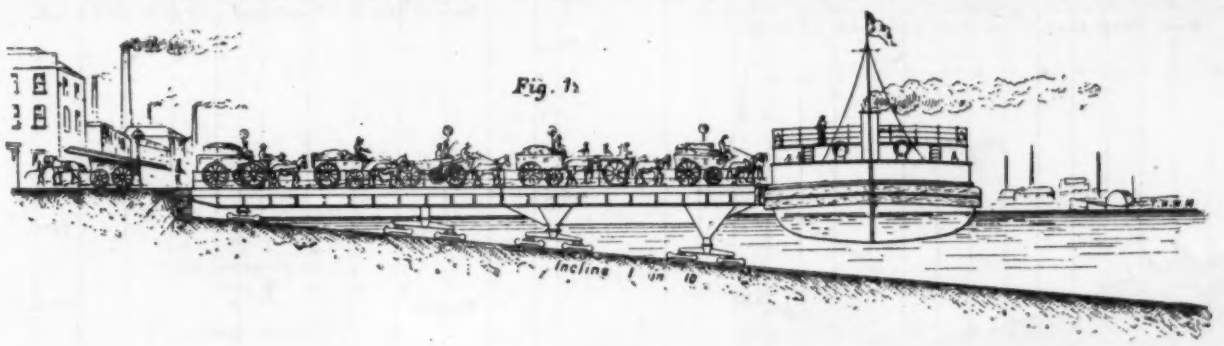
Fig. 12 represents the method of connecting an engine to the main shafting with rope in the place of leather, using one continuous length of hemp rope wound round a number of times, and finally making a turn around two idlers and a tension wheel. The driving wheel, C, may be anywhere from 8 to 16 feet or even more, and making 5,000 or 6,000 feet per minute, or even more. There is but one splice in this rope and an even tension is kept on all the coils, the number of which will vary with the diameter of the wheel. The largest affair in the way of the use of hemp rope for main driving transmission, that has come under our notice, was a pair of twenty-fours by forty-eights, on one shaft (Corliss), which were turning out in the neighborhood of six hundred horse power between them. In this case, however, as many ropes were used as there were grooves in the wheels, which necessitated just that number of splices, and tension was kept on them by one large idler with the same number of grooves as the main pulley. This arrangement, however, cannot be recommended, as it is almost impossible to get an even tension on all the ropes, and there is also a splice for each rope.

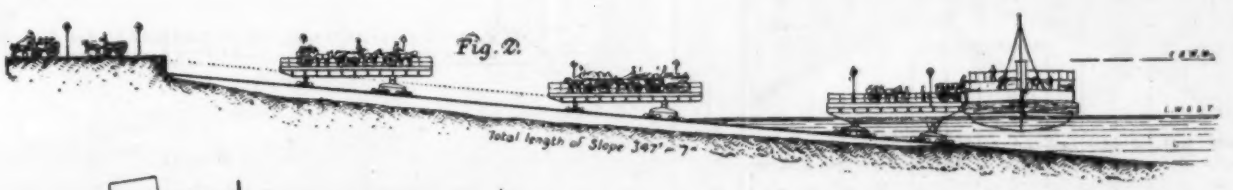
As will be noticed in Fig. 12, but one turn passes around the tension wheel, which controls the tension of the entire number of coils, no matter how many there may be. A being the tension wheel will necessitate an arrangement as described in Fig. 9 and on about the same scale. The advantages of connecting up large engines in this manner cannot be too highly recommended. In the first place, the expense of leather is enormous—$500 is no unusual sum for an engine of three or four hundred horse power, and the pulleys do not have to be very far between centers at that either; in the second place, the noise at high pressure is terrific, and is the worst feature about our otherwise best plants; thirdly, their weight is quite a factor; fourth, they require attention that a rope does not; fifth, it requires a man in the business to put one on right, and sometimes they don't always do it right; sixth, any deviation out of line of the shafting affects the belt, while it has no effect on a rope; seventh, the rope requires less room, and will pass through a round hole little larger than its own diameter.

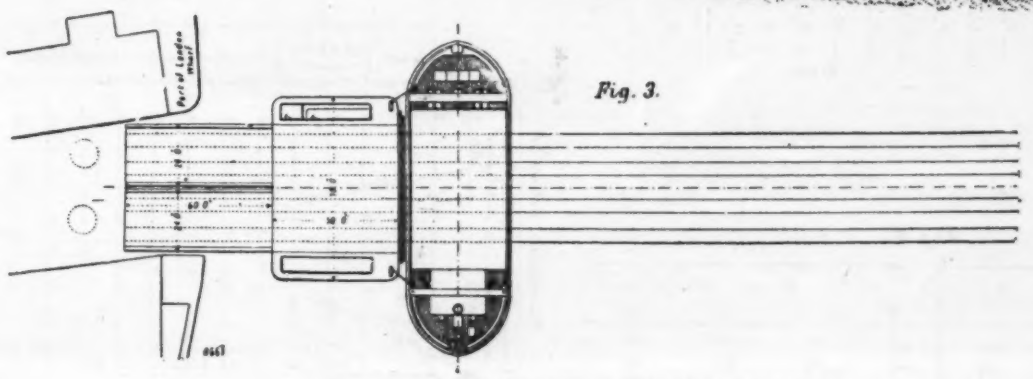
The above points, to say nothing of the first cost, which would be about one thirtieth part of leather, are enough to banish the leather belt for main driving into everlasting oblivion, especially in the minds of those that have had experience with large leather belts. The fact alone that by raising the tension wheel the engine can be turned around by hand for repair or adjustment, is enough to indorse it in the minds of those who have had to do a little pulling on a fly wheel, with the entire shop hitched on.—*E., in Western Electrician.*

THE GREENWICH FERRY.

MORE than two hundred and sixty years have passed since a ferry was instituted at Greenwich, for the conveyance of horse and vehicular traffic across the Thames, but this aged respectability has not up to the present day developed anything from which a lesson of advancement or high development could be learned. Some few years ago, when steam navigation increased greatly, this old time institution quietly passed out of existence, and since then vehicles have been diverted to London bridge, or higher up stream, while foot passengers and such light luggage as could be carried on board have been conveyed from side to side by the steamboats of the Great Eastern Railway Company.







THE GREENWICH STEAM FERRY.

From Britannia Yard, the works of Messrs. Steward & Latham, at Millwall, a commodious steam ferry boat was recently launched, which, says *Engineering*, is destined to make a new departure in the conveyance of all classes of road and rail traffic across the Thames.

The working plant of this ferry will consist of two steamboats 120 ft. long, 40 ft. beam, and 6 ft. draught, two landing stages 70 ft. long and 60 ft. wide, and four traveling platforms 60 ft. long and 23 ft. wide, together with the necessary engines, winding gear, etc. The steamboats are shaped like a spoon at each end, and are to be worked to and fro without turning; the landing stages are rectangular, as also are the traveling platforms.

The diagram given herewith will clearly indicate the difficulties which have to be overcome in gaining access from the ferry boat to the roadway, and *vice versa*, at all times, where, as in this case, the river bottom slopes gradually, and the tide rises and falls 20 ft. The principle for making the connection is as follows: With the rise and fall of the tide, the distance which the ferry boats can approach the bank varies to such an extent that a movable landing stage has been designed to always remain with the same deck level above water. This stage, together with two traveling

platforms, are moved up and down an inclined way, 348 ft. long, sloping riverward at a gradient of 1 in 10. The inclined way is made of a bed of concrete 50 ft. wide and a minimum of 3 ft. deep, with footings on each side sloping 1 to 1 to a depth of 5 ft. below the river bed.

Four lines of rails run longitudinally down the way, with a gauge of 4 ft. 8½ in. and 11 ft. 3 in. centers; the rails are of bridge section 72 lb. to the yard, bolted to 6 in. by 6 in. wrought iron transverse sleepers, 30 lb. to the foot, which are in turn bolted to wrought iron longitudinals 8 in. by 6 in., weighing 33 lb. to the foot. Both transverse and longitudinal sleepers are bedded in the concrete, the rails alone appearing above its surface. The work of laying this roadbed and rails was done at low water, the under-water work being put in with skips from barges moored in the river. As the tide falls, the landing stage will be lowered down the incline, and the traveling platforms will work up and down to convey traffic from the banks. The road approaches on each side are 53 ft. wide, ending in an abutment wall, varying in thickness from 3 ft. at the top to 6 ft. on the footings. The road approaches are 5 ft. 6 in. above Trinity high water mark.

On each side of the river, just behind the abutment walls, two cast iron cylinders are sunk close to each other to a depth of 145 ft. below the level of the roadway. The cylinders are 10 ft. diameter on top, increasing in size by varying cones to 11 ft. 6 in. in diameter at the bottom. The metal varies in thickness from ⅝ in. to 1⅛ in. The decks are of 12 in. by 8 in. creosoted Memel timbers, laid on the flat, running transversely, and covered with 6 in. creosoted Memel block paving. Four lines of tram rails, 72 lb. to the yard, are laid the whole length of the carriage, flush with the top of the wood paving. Longitudinal guard timbers or curbs 14 in. by 8 in. are provided on each side, and protected with steel angles 4 in. by 4 in. by ¾ in. Galvanized handrails 1¼ in. in diameter run on each side the whole length, supported by stanchions 5 ft. apart. Each traveling carriage is carried on twenty-four steel wheels 18 in. diameter fixed under bogies, and so arranged on pivots that the weight is evenly distributed on each. In case of a carriage getting off the rails, it would float itself, together with an additional weight of 50 tons of traffic.

The landing stages are two in number, one on each side of the river. They are rectangular in shape, 70 ft. 2 in. long, 50 ft. wide; depth of steel body, 6 ft. 6 in.; depth over all from surface of roadway, 7 ft. 8 in.; total weight (each) unloaded, 270 tons. The details of construction are similar to that of the traveling platforms, saving that they are constructed in two distinct parts, and subsequently bolted together, also that the tram rails run transversely instead of longitudinally, while on the decks at either end are shelters and the usual offices. Bollards are also fixed on the river side of the stage for the secure mooring of the ferry boats. The stages are carried on thirty-two steel wheels similarly pivoted to those of the traveling platforms. It is proposed to light the road approaches, platforms, stages, and ferry boats with electric light.

The hauling power provided at each side of the river, to work the platforms and stages, consists of two treble geared, double cylinder, high pressure winding engines, with cylinders 14 in. in diameter and 18 in. stroke. The winding drums are 5 ft. in diameter; all winding ropes are of steel wire 1¼ in. in diameter.

The ferry boat has been so designed that should the necessity at any time arise to transport railway traffic and rolling stock from the Great Eastern Railway on the one side to the South-Eastern on the other, it can be done by the present plant, and with this object in view, the approaches, platforms, stages, and boats have been constructed.

The designs for the plant and arrangement of approaches have been made by Messrs. Standfield & Clark.

Fig 1.

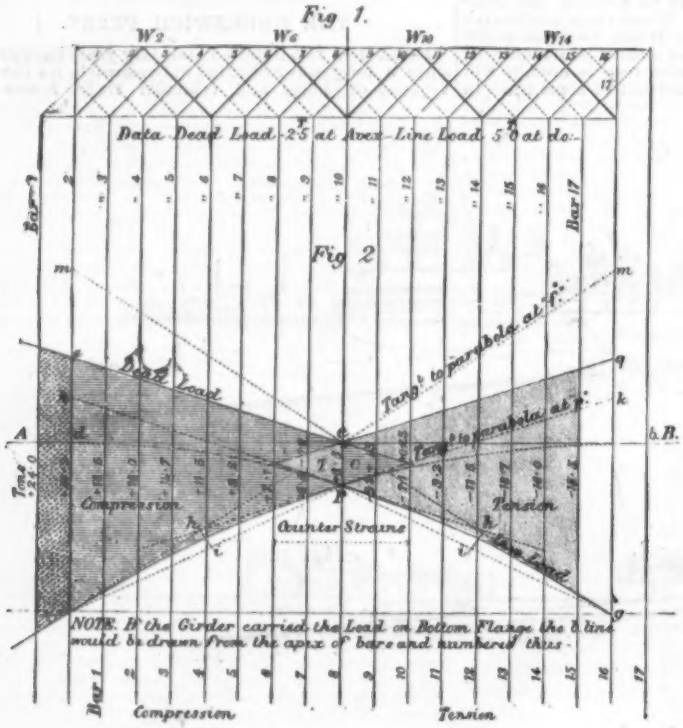


Fig 3.

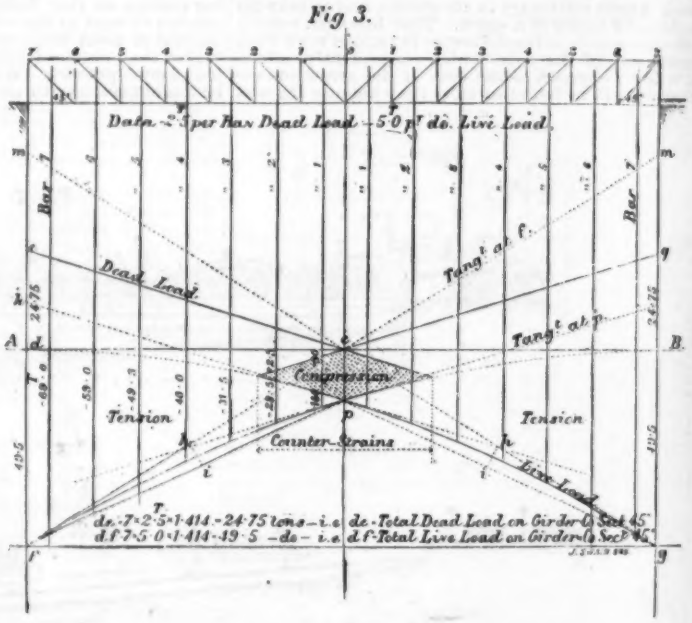

Data 2·5 per Bar Dead Load 5·0 per do. Live Load
Bar 1
Bar 17
Dead Load
Tang.t at f.
Tang.t at p.
Compression
Tension
Counter Strains
Tension
Live Load
dc 7·2·5·1·414 = 24·75 tons — i.e. dc Total Dead Load on Girder Q Sect 45°
df 7·5·0·1·414 = 49·5 — do — i.e. df Total Live Load on Girder Q Sect 45°

Fig 4.

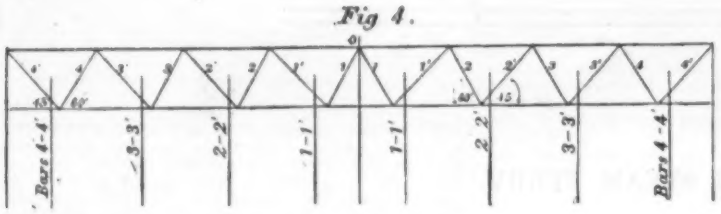
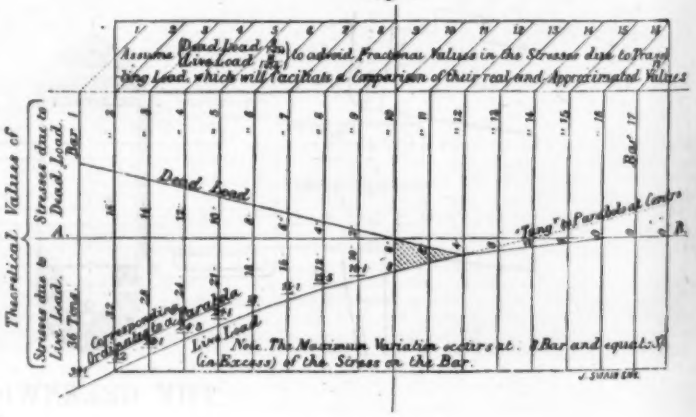


Fig 5.


Assume Dead Load 10 Live Load 15 to avoid Fractional Values in the Stresses due to Travelling Load, which will facilitate a Comparison of their real and Approximated Values
Theoretical Values of
Stresses due to Dead Load. Bar 1
Bar 17
Dead Load
Tang.t to Parabola at Centre
Stresses due to Live Load. 36 Tons.
Corresponding Ordinates to the Parabola
Live Load (in Excess) of the Stress on the Bar.
Note. The Maximum Variation occurs at 9 Bar and equals 1·7

A NEW METHOD OF OBTAINING THE STRESSES ON LATTICES.

By WILLIAM ROBERTSON, C.E.

THE evaluation of the stresses in a lattice girder admits of many varied methods of procedure. Nearly every writer on the subject has some favorite system of his own, which he diligently strives to persuade the student is the best to adopt. Not a few of the methods which have from time to time appeared in *The Engineer* and elsewhere have been demonstrated by an array and manipulation of figures or "tabular numbers," which being added, subtracted, multiplied, or divided, as the case may be, ultimately give, if not the exact, yet a near approximation to the value sought. So intricate indeed are some of those methods that they resemble an arithmetical puzzle, and too often the *modus operandi* fatally escapes the memory, so that invariably reference to an example is necessary to insure the confidence of the student or designer. These methods, besides, look very formidable on paper, and at first sight are not a little embarrassing to the student who is groping his way in the subject; nor are they less irritating to the practical designer, who, as a rule, prefers his scale and compasses to intricate or embarrassing calculations. It appears to me that all the foregoing tabular methods fall in that simplicity which is desirable, from a practical point of view, in dealing with such systems. This complicated treatment arises mainly from the fact that the advocates of such methods are too eager to deduce the "exact mathematical equivalent of the stresses." Within certain limits the attainment of this end may advantageously be neglected. The graphic method, as applied by me, is based upon this consideration; and although exceedingly simple of application to any system of bracing, yet gives so close an approximation to the strictly mathematical values of the stresses that, in ordinary railway girders of, say, 80 ft. to 100 ft. span of the type shown in Fig. 1, the variation on bars No. 4 and No. 16 is only one and a half per cent., and that on bars 8 and 12 three per cent. of their true theoretical value. On all the remaining bars there is practically no variation, in. The contractor for this work, with fine old English crusted conservatism, is doing the sinking of the cylinders with divers, so that it is at once evident that speed of sinking and cost are matters of comparatively small importance.

The cylinders are for the purpose of wells, in which weights will be worked to act as counterpoises to the traveling carriages and landing stage. Sufficient engine power has been provided to overcome the inertia in moving these platforms, and also any additional weight of traffic which they may carry. As the slope on which they travel is 1 in 10, one-tenth of the weight in the wells will balance that of the platforms and landing stage.

The traveling platforms are four in number, two on each side of the river, rectangular in shape; length, 60 ft.; breadth, 23 ft. 2 in. over all; 21 ft. clear width of roadway between curbs; depth of steel body, 2 ft. 7 in.; depth over all to top of wood paving, 3 ft. 9 in.; total weight unloaded (each), 125 tons. They are built of mild steel throughout, all vertical plating being ⅜ in. in thickness; top and bottom skin, ¼ in.; there are four internal longitudinal girders and eleven transverse. Two of the longitudinal and four of the transverse girders form water tight bulkheads, making a total of fifteen separate water tight compartments in each. The longitudinal girders are of ⅜ in. web, flanges composed of two angles, 4 in. by 4 in. by ⅜ in., and a plate of 8 in. by ⅜ in.

Transverse girders ⅜ in. web; flange, one angle, 4 in. by 4 in. by ⅜ in., and a plate of 1 in. by ⅜ in. This latter forms the butt covers for skin plating. The rivets throughout are ⅜ in. in diameter, and 2½ in. pitch.

Explanation of Method.—I will now show the reader how, for any multiple system of latticing, such as Fig. 1, to obtain the maximum values of the stresses on all the bars from a consideration of one brace only. The possibility of this proceeding, I may add in passing, arises from the correlation of each member to the system as a whole, and therefore also mutually one to another. It is convenient in practice to take as our starting point the first full-length brace, as No. 2 in Fig. 1. It will be seen from inspection of the figure that the system to which this diagonal belongs carries the weights W_2, W_6, W_{10}, W_{14}. Now, all that is necessary to be known is the proportion of each of those apex loads—live and dead—which the bar No. 2 carries. These values are readily obtained, being equal to the reaction at left abutment, produced by the loads on the system under consideration. The proportion of dead load thus found × cosecant 45°—the angle of inclination of the bar—we take as one value. The proportion of live load thus found × cosecant 45°, we take as another value. These two values being obtained, we draw a right line A B, through which we draw vertical lines from the toe—or unloaded end—of each numbered bar as shown. Next, from the point d, where the vertical from the toe of No. 2 bar cuts A B,

we set off $d\,e$ = proportion of dead load × cosecant 45°—as before obtained for this bar; also set off $d\,f$ = proportion of live load × cosecant 45°—as previously stated. Thus, since the dead load on each apex of the girder in Fig. 1 is 2·5 tons, we find that the reaction at the toe of No. 2 bar is—

$$\left.\begin{array}{l} \text{For } W_{14} = \frac{1}{2} \times 2{\cdot}5 \text{ tons} \\ \text{" } W_{12} = \frac{2}{2} \times 2{\cdot}5 \text{ "} \\ \text{" } W_{6} = \frac{2}{2} \times 2{\cdot}5 \text{ "} \\ \text{" } W_{2} = \frac{1}{2} \times 2{\cdot}5 \text{ "} \end{array}\right\} = \tfrac{7}{2} \times 2{\cdot}5 = 5 \text{ tons.}$$

and cosecant 45° = 1·414.

Hence $d\,e = 5 \times 1{\cdot}414 = 7{\cdot}07$ tons.

Also since the live load = 5 tons at each apex, or double the dead load, we have only to multiply 7·07 by 2 to obtain $d\,f = 14{\cdot}14$ tons. This is all the calculation that is necessary to enable us to construct our diagram of stress. See Fig. 2.

Construction.—Having set off $d\,e$ and $d\,f$, join e to center of A B at C and produce it till it cuts the curve $f\,b$. The curve $f\,b$ is a parabola, having its vertex at b. Construct a similar figure to right of A B, *i. e.*, make $b\,q = d\,e$ and $b\,g = d\,f$. Join q to C and draw arc of parabola $d\,g$. In practice it will be near enough to make the arcs $f\,p$ and $p\,g$ circular if made to pass through the center of $h\,i$, the offset from the chord $f\,p$ to the point of tangent h—as shown. In order to effect this construction by circular curve, the point p has to be determined by making the center ordinate $c\,p = \frac{1}{4}\,d\,f$, which is a property of the parabolic arc $f\,b$. Scale the intercepts included between the right lines e C, q C and arcs $f\,p$, $p\,g$ for the maximum stresses on the bars. The triangular figures in the center of diagram inclosed by producing the right lines e C and q C and the arcs of parabolas produced beyond p give the counter strain on any diagonal whose vertical projection is cut by them. To find the stress on any broken bar, as No. 1, we have only to project the right line C e and the arc $p\,f$ until they cut its vertical projection from toe, as shown.

Single Systems—Fig. 3.—It will be necessary to point out that in this figure the method of procedure is identical in principle to the foregoing; but the application of the principle is somewhat simpler. Thus we do not require to find the load on any bar of the system as a starting point; we merely set off at either extremity of span, and not on a line projected from any bar, $d\,e$ = ½ total dead load × cosecant 45° = 7 × 2·5 × 1·414 = 24·75 tons. Similarly $d\,f$ = ½ total live load × cosecant 45°. 7 × 5 × 1·414 = 49·5 tons.

The vertical lines representing the bars are then drawn from a point midway between their extremities. With these exceptions the scaling and construction for the maximum stresses are the same as in Fig. 2.

The diagram of stress for the upright struts is the diagram of shear, since cosecant 90° equals unity. Hence, to obtain their values, construct another diagram of stress, making—

$d^1\,e^1$ = ½ total dead load.
$d^1\,f^1$ = ½ total live load.

And proceed as before.

It is to be observed, however, that the verticals in the second diagram representing the struts are drawn in the same positions with reference to span as for the inclined braces correspondingly numbered.

The values of Fig. 3 are scaled, and may be verified by any known means.

Girders of the Form Shown in Fig. 4.—This class of bracing is treated in all respects the same as the preceding, the two values of $d^1\,e^1$ and $d^1\,f^1$ being—

$$d\,e = \frac{\text{total dead load}}{2} \times \text{cosecant } 45°.$$

$$d\,f = \frac{\text{total live load}}{2} \times \text{cosecant } 45°.$$

$$\text{And } d^1\,e^1 = \frac{\text{total dead load}}{2} \times \text{cosecant } 60°.$$

$$d^1\,f^1 = \frac{\text{total live load}}{2} \times \text{cosecant } 60°.$$

The verticals alternately representing the two sets of bars, as in the preceding case, Fig. 3.

Fig. 5 gives the following percentage of excess in the value of the stresses on the various bars of Fig. 1, as determined by the diagram of stress. The ratio of live to dead load being as 2 to 1.

Bars Nos.	Excess per cent. of stress.	
1	0·20	under ¼ per cent.
2	*nil*	
3 and 17	0·24	under 1½ per cent.
4 and 16	1·40	
5 and 15	0·32	under ⅓ per cent.
6 and 14	*nil*	
7 and 13	0 48	
8 and 12	3·12	maximum.
9 and 11	0·83	under 1 per cent.
10	*nil*	

Note.—In any multiple system, as Fig. 1, if absolute accuracy be required in the counterbraced areas, tangents to the parabolas at center must be drawn to form those areas, as will be seen from inspection of this figure. The areas shown in Fig. 2 are slightly in excess.

A thorough acquaintance with the method of procedure in the two principal cases, Fig. 1 and Fig. 3, will, I feel confident, enable any one having the slightest acquaintance with the theory of stress in girders to become thorough master of that hitherto mystifying and, to many plodding students, perplexing problem of lattice bracing.—*London Engineer.*

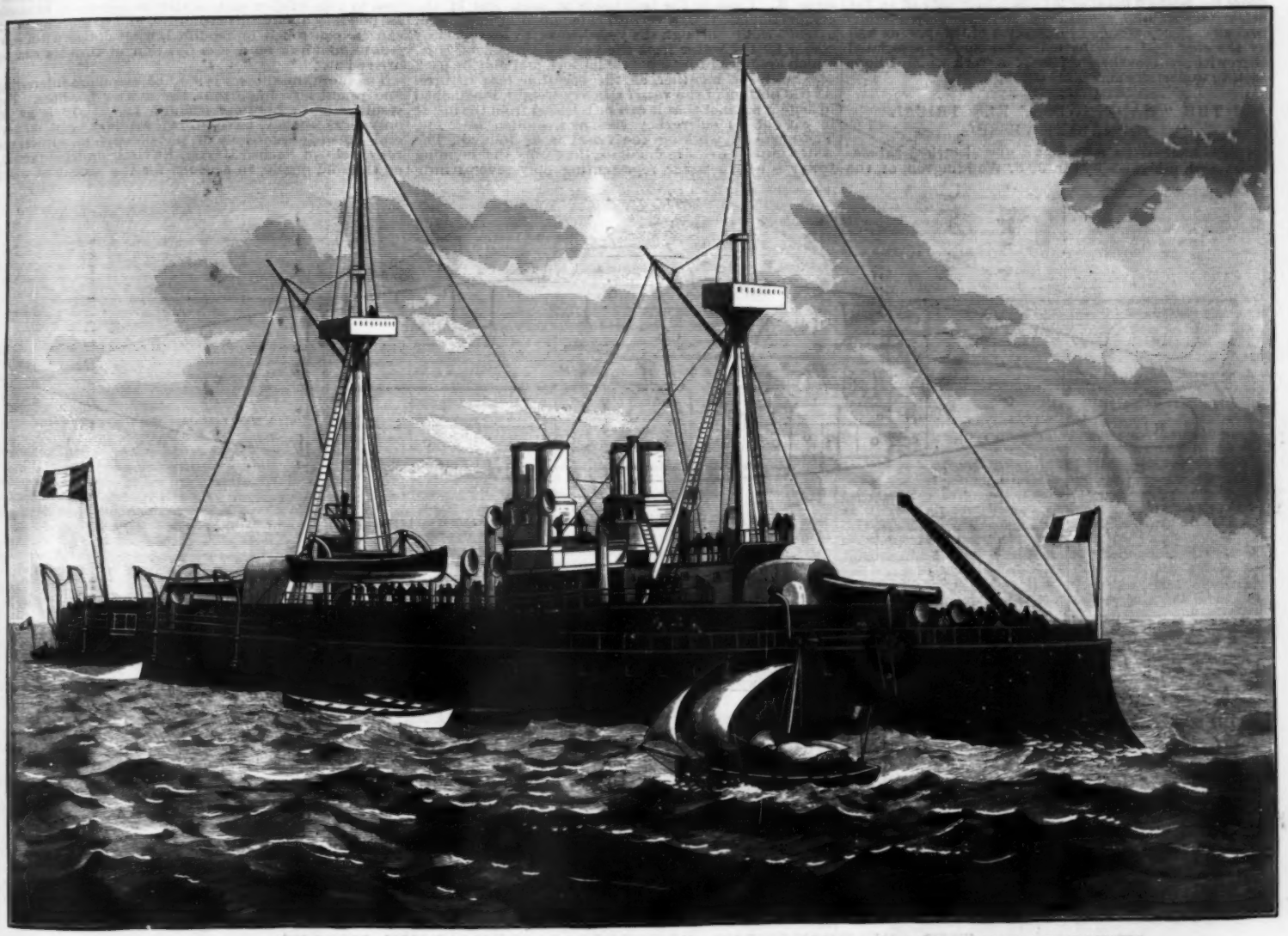
THE great value of isochromatic plates in micro-photography has been demonstrated by Dr. Crookshank, who exhibited to the Royal Microscopical Society of London micro-photographs of bacteria obtained without staining the objects with aniline, as in Koch's process, and he has still more recently exhibited a photograph showing the flagella of a vibrio.

NEW FRENCH ARMORCLAD CRUISER LE TERRIBLE.

IT appears that the fleet of armorclads, which not long since appeared to have grown senile in the presence of the more modern torpedo boat, is now more in favor than ever with the navy men. All the great nations are taking every step to increase the efficiency of their navies, both in constructing ships of enormous tonnage and in constructing new types of ships. Without leaving out of sight the necessity for a fleet of torpedo boats, France ought to follow this movement. The maneuvers of last year have not dethroned the ironclad. Those of this year, we are ready to affirm, will not lessen the prestige of those magnificent ships which are the honor of our navy. Let us rejoice at this most recent addition to the fleet of a new type of cruiser.

The Terrible, which was launched in 1881, satisfactorily finished its trial test during the latter part of the winter. It is now entirely finished. This ship is a mate of the Requin, which was constructed in the shipyards of the Loire, and which was launched in 1885.

The hull is of iron and steel, and measures 280 ft. in length, 59 ft. beam, with a draught of 23 ft. 9 in., 7,168 tons displacement, with armor plating 50 centimeters in thickness amidships, 37 centimeters forward, and 33 centimeters aft. It is provided with 12 boilers.



THE NEW FRENCH ARMORED WAR SHIP TERRIBLE—7,200 TONS DISPLACEMENT.

The armament, mounted on the forecastle, consists of two cannons of 47 centimeters, four cannons of 10 centimeters, and ten machine guns. There is a complement of 332 men.—*L'Illustration.*

THE FORMATION OF ALLOYS.

THE following is an abstract of a note read before the Philosophical Society by William Hallock, of the United States Geological Survey, Feb. 18, 1888:

In the *Berichte der chemischen Gesellschaft*, vol. xv., 1882, pp. 595–597, W. Spring describes the formation of alloys by submitting the filings of the constituent metals to high pressure, without appreciable rise in temperature. Wood's alloy of cadmium, tin, lead, and bismuth be produced by mixing proper weights of the filings of these metals, and subjecting them to a pressure of 7,000 atmospheres. The block thus obtained was again filed up, and subjected to the same pressure.

In this way a block of metal was produced which possessed the physical properties of ordinary Wood's alloy, formed by melting the mixed constituents.

W. Chandler Roberts repeated this experiment (*Chemical News*, vol. xlv., 1882, p. 231), and verified Mr. Sping's results.

In seeking an explanation of the above phenomenon satisfactory to myself, I reasoned that if at any time during the first compression, the subsequent filing, or the second compression, anywhere throughout the mass, the constituent metals were in contact, at that point there would be a minute globule of the alloy—a molecule of alloy, as it were. If, now, the temperature of the block, either during compression or subsequent-

ly, be raised to 70° C., then that molecule of alloy will fuse, and act as a solvent upon the surrounding metals till the whole mass is fused.

If my idea was correct, I concluded that perhaps I could produce the result without pressure, giving more time and an appropriate temperature to the substance.

The filed metals in the proper proportions were mixed, and packed into the bottom of a "sealed tube," such as is used for blowpipe work, using no greater pressure than could be conveniently exerted with a piece of wire, one-eighth of an inch in diameter, held between the thumb and finger. This tube was hung in the water bath of the laboratory overnight (eighteen hours), thus maintaining it At a temperature of from 98° to 100° C. On examination, the filings had settled down considerably. The tube was then struck upon the table, jarring them down still more, and in an hour or two the whole was a molten globule.

The experiment was repeated, using larger quantities packed in with a lead pencil, and occasionally pressing the mass together with the pencil, producing twenty or thirty grains of alloy. Since then, tin and lead have been fused together at 200° C., tin melting only at 230° C. Also sodium and potassium at ordinary temperatures (20° C.), the first melting at about 90° C., and the latter at about 60° C. Thus I proposed the law, that *an alloy can be formed out of the constituents at a temperature above the melting point of the alloy, although it be far below that of any constituent, with no (appreciable) pressure.* The extended verification of this law, as well as the electrical and thermal phenomena associated therewith, will be the subject of a work which I hope soon to undertake and carry through.

THE "WADDINGTON" ELECTRICAL SUBMARINE VESSEL.

OUR illustrations represent a new electrical submarine vessel, designed by Mr. J. F. Waddington, of the firm of Messrs. J. F. Waddington & Co., ship builders and engineers, Seacombe, near Liverpool, which has recently undergone trials before representatives of the British and foreign governments; Count Candiani, of the Italian navy, and other gentlemen accompanying the inventor in the vessel, below water, on various occasions. The length of this vessel is 37 ft. over all, and her diameter amidships is 6 ft., tapering in a curve to a point at each end. On the top of the vessel is the conning tower, A, provided with ports at the sides and a water tight scuttle, Q, on top for entering the interior. The vessel is divided by the bulkheads, B B, into three compartments, of which the two end ones, C C, are used for storing the supply of compressed air, while the center one is occupied by the driving, pumping, and steering apparatus.

The electricity used for working the motor is stored in forty-five large accumulator cells, D, which have a capacity of 660 ampere hours each, and are connected in series to an electromotor, E, which drives the propeller, F, direct at about 750 revolutions per minute. The motor when working at full speed uses a current of about 66 amperes and 90 volts, developing 7·96 electrical horse power, which would drive the vessel for ten hours at a rate of eight miles an hour, thereby enabling the vessel to go eighty miles at full speed without replenishing the accumulators, while at half speed she would travel 110, and at slow speed 150 miles. The great advantages the inventor claims in using electricity are that when once charged the vessel is ready to start at a moment's notice; that when stopped, the motive power is not subject to waste, as in the case of steam power; and that no heat or poisonous gases are given off to pollute the air in the vessel, which is an important feature in submarine vessels; also that a small sized class of these vessels can be carried on a man-of-war's davits, ready for instant use, the same as any ordinary launch.

All the levers for maneuvering the boat are arranged amidships, within easy reach of the steersman, so that he can control the movements of the vessel while looking out of the conning tower. A second man accompanies the steersman, to assist in case of emergency, so that the crew of the boat consists of two men only. On either side of the vessel large water ballast tanks, G, are provided, by filling which the buoyancy of the vessel may be reduced by several hundredweights when preparing to dive. At the after end are arranged two vertical rudders, H H, and two horizontal ones, I I, the latter ones being used for keeping the vessel on an "even keel" when moving under water. It was found necessary to make the rudders, I I, act automatically, as a man might lose his presence of mind when most required.

The inventor at first provided a pendulum suspended from the top of the vessel and connected to the rudders, I I. But it did not answer readily enough to the action of the vessel, and he now adopts an electromotor, K, working into worm gearing, and arranged in such a manner that the slightest cant up or down causes the rudders to be put over to meet it, and then stopped in the same manner as a steam steering gear. At each side of the vessel balanced side planes, L L, are provided, which may be inclined at different angles by the lever, M. Close to the bulkheads at each end of the compartments, C C, a vertical tube, open at each end, extends right through the vessel so as to leave a clear course for the water from the vertical propellers, N N, which are worked by separate motors, and may be used separately or together, as the occasion may require. At the bottom of the vessel a heavy weight is attached in such a manner that it can be released from the inside in case of an emergency, such as a sudden leak, etc. The mode of working the vessel is as follows: The water tanks, G G, are filled, so that only the conning tower is above water, representing only several hundredweights of buoyancy, the motor started, and a speed of say four to five miles an hour attained. Then the side planes are inclined by means of the lever, M, and the vessel thereby submerged. By regulating the angle of the side planes and the speed, any reasonable depth may be maintained.

If it be desirable to submerge the vessel without forward motion, only the vertical propellers are used, and any reasonable depth may be maintained by regulating their speed. These vertical propellers may also be used for regulating the depth when the vessel is moving onward, but the side planes are considered preferable in that case. The fresh air is drawn from the two end compartments, C C, and the bad air escapes through a valve as soon as the pressure inside becomes greater than that outside.

But the compressed air need only be used when staying below a lengthened period, as the center compartment contains air sufficient for two men for six hours without drawing upon the supply of compressed air. The vessel carries two locomotive torpedoes, O, one on each side, secured by grips, which can be opened from the inside of the vessel. By releasing these grips the propelling motor of the torpedo is started, and it shoots ahead of the submarine vessel. A mine torpedo, P, is also provided for attacking any vessel at anchor with the torpedo nettings down, and which can be fired from a distance by an electric wire paid out from the submarine vessel. The dotted lines indicate portable guard rails and stanchions, which are put in place when the boat is above water—a very necessary precaution in a seaway. Mr. Waddington is still engaged in further perfecting his invention, which can be worked by compressed air as well as by electricity, and hopes at no distant date to rival the present high speed surface torpedo boats.—*Industries.*

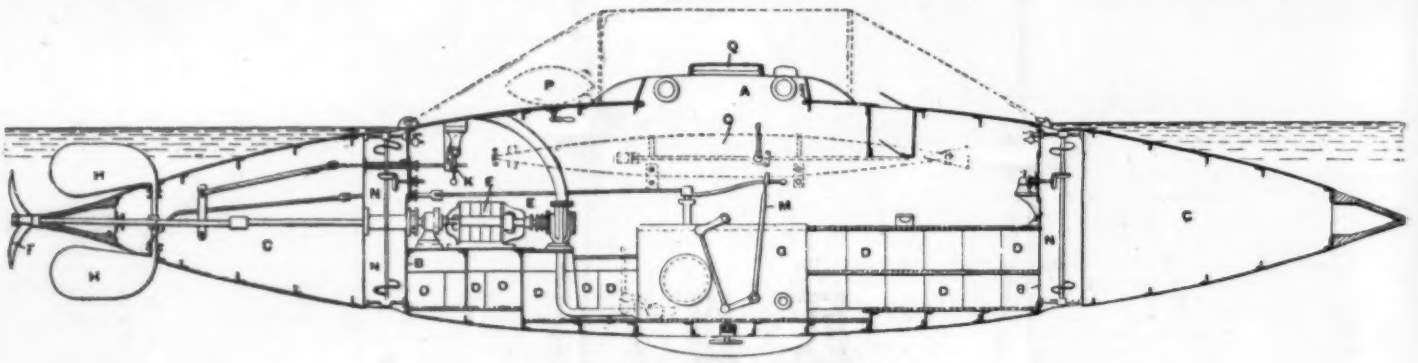


FIG. 1.—SECTIONAL ELEVATION.

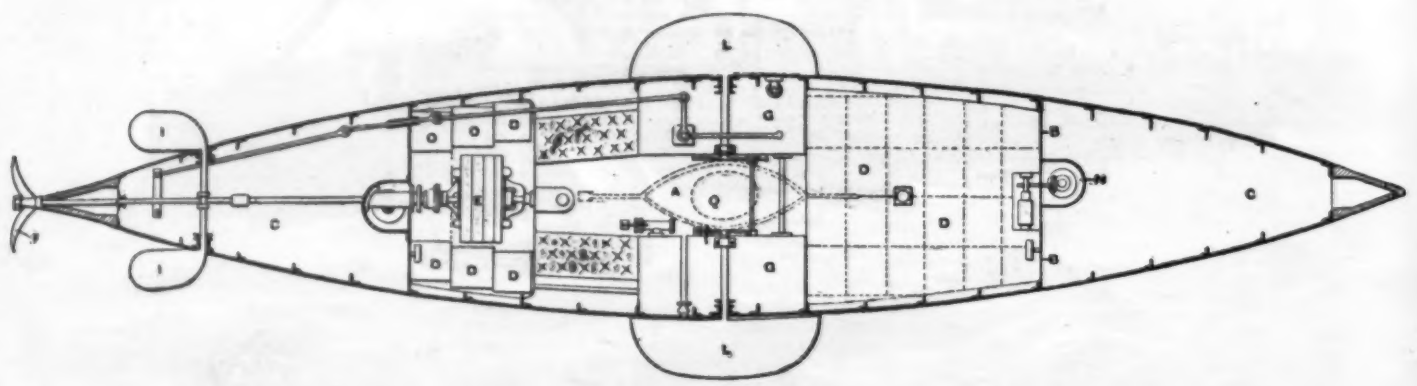


FIG. 2.—SECTIONAL PLAN.

[NATURE.]

TIMBER, AND SOME OF ITS DISEASES.*

By H. MARSHALL WARD.

II.

THE enormous variety presented by the hundreds of different kinds of woods known or used in different countries depends for the most part on such peculiarities as I have referred to above, together with some others which have not as yet been touched upon. Everybody knows something of the multitudinous uses to which timber is put, and a little reflection will show that these uses are dependent upon certain general properties of the timber. Speaking broadly, the chief properties are its weight, hardness, elasticity, cohesion, and power of resisting strains, etc., in various directions, its durability in air and in water, and so forth; moreover, special uses demand special properties of other kinds also, and the color, closeness of texture, capacity for receiving polish, etc., come into consideration.

Now, there is no doubt that the structure of the wood as formed by the cambium is the chief factor in deciding these technological characters; it is not the only factor, but it is the most important one. Consequently no surprise can be felt that those who are interested in timber have of late years turned their attention to this subject with a view to ascertain as much as possible about this structure, and to see whether it can be controlled or modified, what dangers it is subject to, and how far a classification of timbers can be arrived at.

The more the subject is studied, the more interesting and practically important the matter becomes. The results already obtained (though the study is as yet only in its infancy) have thrown brilliant light on several burning questions of physiology—as witness the researches of Sachs, Hartig, Elfving, and Godlewski, on that old puzzle, to account for the ascent of water in tall trees. The study is, moreover, of first importance for the comprehension of the destruction of timber, due to "dry rot" and the parasites which cause diseases in standing trees, as is shown by the brilliant researches of Prof. R. Hartig on the destruction of timber by Hymenomycetes; and again as yielding trustworthy information as to the value of different kinds of timber in the arts, and enabling us to recognize foreign or new woods of value. In support of this statement it is only necessary to call attention to the "Manual of Indian Timbers," prepared for the Indian government by Mr. Gamble; or to refer to the beautiful series of wood sections prepared by Nordlinger.

It is, of course, impossible in an article like the present to do more than touch upon a few of the more interesting points in this connection; but I may shortly summarize one or two of the more striking of these peculiarities of timbers, if only to show how well worth further investigation the matter is.

Many timbers, from both tropical and temperate climates, exhibit the so-called "annual rings" on the transverse section; but this is not the case with all. Most European timbers, for instance, are clearly composed of such layers; but in some cases the layers ("rings" on the transverse section) are so narrow and numerous that the unaided eye can scarcely distinguish them, or the differences between the spring and autumn wood are so indistinctly marked that they may appear to be absent, or are at least obscure, as in the olive, holly, and orange, for instance. It is in the tropics, however, that timber without annual rings is most common, chiefly because the seasons of growth are not sufficiently separated by periods of rest to cause the formation of sharply marked zones, corresponding to

* Continued from SUPPLEMENT, No. 637, page 10173.

spring and autumn wood, *e. g.*, some Indian Leguminosæ, etc. Zones of tissue of other kinds often occur in such timbers, and have to be understood, since they affect the properties of the wood very differently, *e. g.*, some of the figs.

None of the conifers or dicotyledonous trees, however, are devoid of medullary rays, and distinctive characters are based on the breadth and numbers of these: as examples for contrast may be cited the fine rays of the pines and firs, and the coarse, obvious ones of the oaks.

Again, the prominence or minuteness, or even (Coniferæ) absence, of vessels in the secondary wood afford characters for classification. The contrast between the extremely small vessels of the box and the very large ones of some oaks and the chestnut, for instance, is too striking to be overlooked. Then, again, in some timbers the vessels are distributed more or less equably throughout the "annual ring," as in the alder, some willows and poplars, etc.; whereas in the chestnut and others they are especially grouped at the inner side of the annual zone (*i. e.*, in the spring wood), and

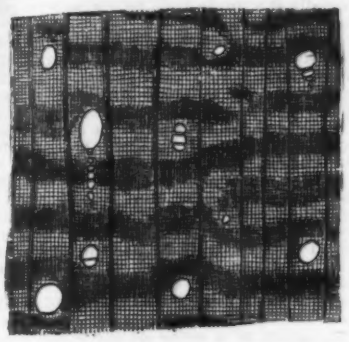


FIG. 7.—Transverse section of the wood of *Pongamia glabra*, Vent., selected to show a type of timber not uncommon in India. No distinct annual rings appear, but the wood is traversed by wavy bands of tissue, which may run into one another or not. The vessels ("pores") are few and scattered, and differ in size; the medullary rays well marked, but not large. To this type—differing in other details—belong many species of figs, acacias, and other Asiatic Leguminosæ, etc.

in some cases these groupings are such as to form characteristic figures on the transverse section, as in some oaks, *Rhamnus*, etc. In the woodcuts (Figs. 7–10) I have given four examples illustrating a few of the chief points here adverted to.

Passing over peculiar appearances due to the distribution of the wood parenchyma between the vessels, as exemplified by the figs and the maples, as well as minor but conspicuous features which enable experts to recognize the timber of certain trees almost at a glance, I may now proceed to indicate a few other peculiarities which distinguish different timbers.

The weight of equal volumes of different woods differs more than is commonly supposed, and there are certain details to be considered in employing weight as a criterion which have not always been sufficiently kept in mind.

A cubic foot of "seasoned" timber of the Indian tree *Hardwickia binata* weighs about 80 lb. to 84 lb., while a cubic foot of *Bombax malabaricum* may weigh less than 20 lb., and all gradations are possible with various timbers between these or even greater extremes. If we keep in mind the structure of wood, it is evident that the weights of equal volumes of merely seasoned timber will yield only approximate results. For even if the seasoning, weighing, etc., are effected in a constant atmosphere, woods which differ in "porosity" and other properties will differ in the extent to which they absorb moisture from damp air or give it up to dry air.

In our climate, timber which is felled in April or May, generally speaking, contains much more water than if felled in July and August; it is, in fact, no uncommon event to find that about half the weight, or even more, of a piece of recently felled timber is due to the water it contains. If this water is driven off by heat, and the piece of wood thoroughly dried, the lat-

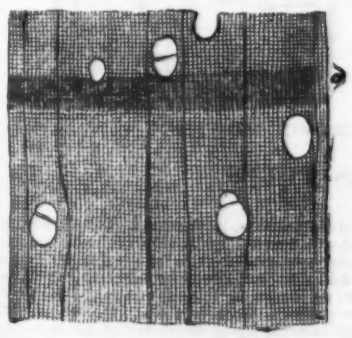


FIG. 8.—Transverse section of wood of *Tamarindus indica*, Linn., selected to show a not uncommon type of Asiatic timber. The annual rings are indistinct, but occasionally indicated by denser tissue (*a*). The vessels are fairly large and few, and scattered much as in Fig. 7, but there are no such broad bands of cells as there.

ter will be found to weigh so much less, but it will increase in weight gradually as it imbibes moisture again.

Now it happens that the weight of a piece of timber, compared with that of an equal volume of some standard substance—in other words, the specific weight—is of very great importance, because several other properties of wood stand in relation with it, *e. g.*, the hardness, durability, value as fuel, tendency to shrink, etc. Fresh cut timber in very many cases contains on an average about 45 to 50 per cent. of its weight of water, and if seasoned in the ordinary way, this is reduced to about 15 to 20 per cent.; but the fresh timber also contains air, as may easily be shown by warming one end at the fire or in hot water and watching the bubbles driven out, and the seasoned timber contains less water and more air in proportion, so that we see how many sources of error are possible in the usual weighings of timber. At the same time, many comparative weighings of equal volumes of well seasoned timber do yield results which are of rough practical use.

The fact is that the so-called "specific weight" of timber, as usually given, is not the specific gravity of the wood substance, but of that *plus* entangled air and water. It is interesting to note that, although we associate the property of floating with wood, timber deprived of its air will sink rapidly, being about half as heavy again as water, volume for volume.

The point just now, however, is not to discuss these matters in detail, but rather to indicate that, other things equal, the density of a piece of timber will be greater, the more of that closely packed, thick walled autumn wood it contains; while the timber will be specifically lighter and contain more air when dry, the greater the proportion of the looser, thin walled spring wood in its "annual rings." In other words, if we could induce the cambium to form more autumn wood and less spring wood in each annual ring, we could improve the quality of the timber; and, in view of the statement which has been made, to the effect that large quantities of timber of poor quality reach the Continental wood yards every year, this is obviously an important question, or at any rate may become one.

The remainder of this article must be devoted to this question alone, though it should be mentioned that several other questions of scientific and practical importance are connected with it.

The first point to notice is that the cambium cells, like all other living cells which grow and divide, are sensitive to the action of the environment. If the temperature is too high or too low, their activity is affected and may even be brought to an end; if the supply of oxygen is too small, their life must cease, since they need oxygen for respiration just as do other living cells; if they are deprived of water, they cannot grow—and if they cease to grow they cannot divide, and any shortcomings in the matter of water supply will have for effect a diminution of activity on the part of the cambium. The same is true of the supply of food substances: certain mineral salts brought up from the soil through the roots, and certain organic substances (especially proteids and carbohydrates) prepared in the leaves, are as necessary to the life of a cambium cell as they are to the life of other cells in the plant. Now, since the manufacture of these organic substances depends on the exposure of the green leaves to the light, in an atmosphere containing small quantities of carbon dioxide, and since the quantities manufactured are in direct relation to the area of the leaf surface—the size and numbers of the leaves—it is obvious that the proper nourishment of the cambium is directly dependent on the development of the crown of foliage in a tree. Again, since the amount of water (and mineral salts dissolved in it) will vary with the larger or smaller area of the rootlets and absorbing root hairs (other things equal), this also becomes a factor directly affecting our problem. Of the interdependences of other kinds between these various factors we cannot here speak, since they would carry the argument too far for the space at command. Some of them are obvious, but there are correlations of a subtile and complex nature also.

First as to temperature. The dormant condition of the cambium in our European winter is directly dependent on the low temperature, as the sun's rays warm the environment, the cambial cells begin to grow and divide again.

The solar heat acts in two ways: it warms the soil and air and it warms the plant. Wood, however, is a bad conductor of heat, and the trunk of a tree is covered by the thick corky bark, also an extremely bad conductor, and it would probably need the greater part of the early summer to raise the temperature of the cambium sufficiently for activity in the lower parts of a tree by direct solar heat: the small twigs, on the contrary, which are covered by a thin layer of cortex, and epidermis, are no doubt thus warmed fairly rapidly, and their early awakening is to be referred to this cause.

The cambium in the trunk, however, is not raised to the requisite temperature until the water passing up through the wood from the roots is sufficiently warm to transmit some of the heat brought with it from the soil to the cells of the cambium. This also is a somewhat slow process, for it takes some time for the sun's rays to raise the temperature of the soil while the days are short and the nights cold. Hartig has shown that the cambium in the lower part of the trunk of a tree may be still dormant three weeks or a month after it has begun to act in the twigs and small branches; and it has also been pointed out that trees standing in open sunny situations begin to renew their growth earlier than trees of the same species growing in shady or crowded plantations, where the moss and leaf mould, etc., prevent the sun from warming the soil and roots so quickly.

These observations have also a direct bearing on the later renewal of cambial activity in trees growing on mountains or in high latitudes. Moreover, though I cannot here open up this interesting subject in detail, these facts have their connection with the dying off of temperate trees in the tropics, as well as with the killing of trees by frost in climates like our own. One important practical point in this connection may be adverted to. Growers of conifers are well aware that certain species cannot be safely grown in this country (or only in favored spots) because the sun's rays rouse them to activity at a time when spring frosts are still common at night, and their young tissues are destroyed by the frosts. Prof. R. Hartig has pointed out a very instructive case. The larch is an Alpine plant, growing naturally at elevations where the temperature of the soil is not high enough to communicate the necessary stimulus to the cambium until the end of May or June. Larches growing in the lowlands, however, are apt to begin their renewed growth in April, and frosted stems are a common result, a point which (as the renowned botanist just referred to also showed) has an important bearing on that vexed question—the "larch disease."

The supply of oxygen to the cambium is chiefly dependent on the supply of water from the roots, and the aeration of the stem generally. The water begins to ascend only when the soil is warm enough to enable the root hairs to act, and new ones to be developed, and the supply of mineral salts goes hand in hand with that of water.

Now comes in the question of the sources of the organic substances. There is no doubt that the cambium at first takes its supply of food materials from the stores which have been laid by, in the medullary rays, etc., at the conclusion of the preceding year; and it is known that special arrangements exist in the wood and cortex to provide for this when the water and oxygen arrive at the seat of activity.

Assuming that all the conditions referred to are favorable, the cambium cells become filled with water in which the necessary substances are dissolved, and distended (become turgid, or turgescent, as it is technically called) sufficiently for growth. Speaking generally, and with reference chiefly to the trunk of the tree, which yields the timber, the distention of the cells is followed by growth in the direction of a radius of the stem, and division follows in the vertical plane, tangential to the stem. Then the processes already described with reference to Fig. 5 repeat themselves, and the trunk of the tree grows in thickness.

Now it is obvious that the thickening of the mass of timber inside the cylinder of cambium must exert

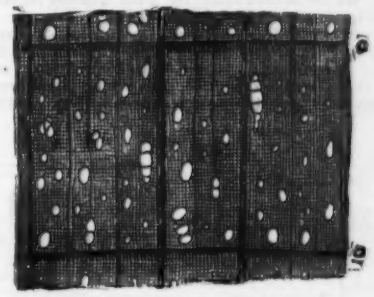


FIG. 9.—Transverse section of the wood of *Acer pseudo-platanus*, selected to show a type of timber common in Europe. The annual rings (*a*) are well marked and regular. The vessels are small and numerous, and scattered somewhat equally over the whole breadth of the ring. The medullary rays are numerous, some broad, some fine. Many European timbers (beech, hornbeam, lime, etc.) agree with this type, except in details.

pressure on the cortex and bark—must distend them elastically, in fact—and some ingenious experiments have been made by De Vries and others to show that this pressure has an effect in modifying the radial diameter of the cells and vessels formed by the cambium. Several observers have promulgated or accepted the view that the differences between so-called spring and autumn wood are due to the variations in pressure of the cortex on the cambium; but the view has lately gained ground, based on experimental evidence, that these differences are matters of nutrition, and a recent investigator has declared that the thick walled elements and small sparse vessels characteristic of autumn wood can be produced, so to speak, at will, by altering the conditions of nutrition.

It is authoritatively stated that the pines of the cold northern countries are preferred for ships' masts in Europe, and that the wood cutters and turners of Germany prize especially the timber of firs grown at high elevations in the Bavarian Alps. Now the most striking peculiarity of the timbers referred to is the even quality of the wood throughout; the annual rings are close and show less of the sharp contrasts between thin walled spring wood and thick walled autumn wood, and Hartig suggested that this is due to the conditions of their nutrition, and in the following way: The trees at high elevations have their cambium lying dormant for a longer period, and the thickening process does not begin in the lower parts of the trunk until the days are rapidly lengthening and the sun's rays gaining more and more power; the consequence is that the spring is already drawing to a close when the cambium cells begin to grow and divide, and hence they perform their functions vigorously from the first.

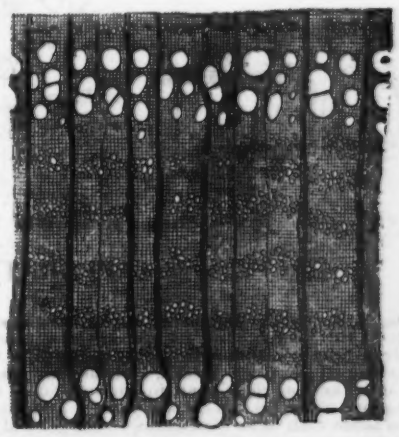


FIG. 10.—Transverse section of wood of the common elm (*Ulmus campestris*), selected as a common type of European timber. The annual rings are very distinct, owing to the large vessels in the spring wood; the vessels formed during the summer and autumn are grouped in bands or zones. The medullary rays are numerous, but not very broad. The oak, ash, chestnut, and others agree in the main with this type, differing chiefly in the *mode of grouping* of the smaller vessels, and in the *breadth* of the medullary rays.

One of the most interesting experiments in this connection came under my observation last summer, owing to the kindness of Prof. Hartig. There is a plantation of larches at Freising near Munich, with young beeches growing under the shade of the larches. The latter are seventy years old, and are excellent trees in every way. About twenty years ago these larches were deteriorating seriously, and were subsequently "under planted" with beech, as foresters say—*i. e.*, beech plants were introduced under the shade of the larches. The recovery of the latter is remarkable, and dates from the period when the under planting was made.

The explanation is based on the observation that

the fallen beech leaves keep the soil covered, and protect it from being warmed too early in the spring by the heat of the sun's rays. This delays the spring growth of the larches; their cambium is not awakened into renewed activity until three weeks or a month later than was previously the case, and hence they are not severely tried by the spring frosts, and the cambium is vigorously and continuously active from the first.

But this is not all. The timber is much improved; the annual rings contain a smaller proportion of soft, light spring wood, and more of the desirable summer and autumn wood consisting of closely packed, thick walled elements. The explanation of this is that the spring growth is delayed until the weather and soil are warmer, and the young leaves in full activity; whence the cambium is better nourished from the first, and forms better tracheides throughout its whole active period. Such a result in itself is sufficient to repay the investigations of the botanist into the conditions which rule the formation of timber, but this is by no means the only outcome of researches such as those carried on so assiduously by Prof. Hartig in Munich, and by other vegetable physiologists.

It is easy to understand that the toughness, elasticity, and such like quantities of a piece of timber, depend on the character of the tracheides, fibers, etc., of which it is chiefly composed. Investigations are showing that the length of such fibers differs in different parts of the tree. Sanio has already demonstrated that in the Scotch pine, for instance, the tracheides differ in length at different heights in the same trunk, becoming longer as we ascend, and also are longer in the outer annual rings than in the inner ones as the tree grows older, up to a certain period; and this is in accordance with other statements to the general effect that for many years the wood improves, and that better wood is found at the base of the trunk.

However, it is impossible to pursue these subjects in all their details; my object is served by showing how well worthy of the necessary scientific study is timber even to those who are only concerned with it in its usual conditions, and within those limits of variation in structure and function which constitute health. The importance of the subject in connection with the modern development of biology along the grand road of comparative physiology does not need insisting upon here. It will be the object of further articles to show how it is, if possible, still more important and interesting to know the structure and functions of healthy timber, before the practical man can understand the diseases to which timber is subject. At the same time it must be clearly borne in mind that these are but sketches of the subject; for it is as true of trees and their diseases as it is of men and human diseases, if you would be trainers and doctors you must know thoroughly the structures and peculiarities of the beings which are to be under your care.

NEW PROCESSES OF MANUFACTURING SEAMLESS TUBES.

THE manufacture of tubes without soldering has, in recent years been the object of persistent research and important labors that have originated several new processes, among which we would specially mention those of Messrs. Flotow Leidig, Robertson, and Mannesmann.

The first of these processes, which is of limited application, employs a method of longitudinal drawing upon a stationary mandrel. The two others have recourse to a helicoidal or diagonal drawing, accompanied with a cooling of the metal, on a fixed or movable mandrel, by the aid of revolving draw plates or rollers having a differential rotation. They constitute two of the most remarkable examples of the flow of solids through metals.

Up to the present, the Robertson process appears to have been applied with the most advantage to the working of plastic metals (copper, tin, bronze, etc.) in a cold state, while that of Mannesmann, which is of the most remarkable boldness and originality, is perfectly adapted to the manufacture of iron and steel tubes. This mode of manufacture, which will soon be worked on a large scale, will probably produce, at a low price, absolutely homogeneous seamless tubes, whose metal, far from being weakened, will rather be strengthened by the operations that it undergoes. We have, therefore, not hesitated to describe it, although, by very reason of its originality, it is quite difficult to explain by simple figures.

THE FLOTOW LEIDIG PROCESS.

In the process of drawing employed by Messrs. Wilhelm von Flotow and Hermann Leidig, of the Dantzig Arms Manufactory, the mandrel, *d* (Figs. 1 to 4), is fixed and the ingot, *l*, is drawn between the head, *v*, of the mandrel and the draw plate, *m*, in such a way as to convert it into a tube, *t*, of smaller diameter. To this effect, the ingot is held by its tenon and mortise extremity, *e*, in the head, *s*, which is movable under the action of the screws, *o* and *p*.

Though successively reducing the diameter of the draw plate, this process permits of drawing out a tube conical externally, like a gun barrel, for example (Fig. 4), which is obtained by drawing the tube all entire to the diameter, 1, then the part, 7-2, to the diameter, 2, etc. But it is equally applicable to the manufacture of iron and steel boiler tubes.

THE ROBERTSON PROCESS.

The mandrel, D (Figs. 5 to 8), of the apparatus of Mr. James Robertson, of Glasgow, revolves within the ingot, C, and is at the same time pushed forward by the hydraulic press, E. The rotary motion is given by the train, I H G, the pinion, H, of which is fixed by tongue and groove to the shaft, I. The draw-plate, A, which is firmly keyed between the jaws, B, is slightly conical, so that the ingot, C, fixes itself in the die by the very pressure of the mandrel. The form of the mandrels varies according to the metal and temperature of the ingot. The one shown of actual size in Figs. 9 to 12 serves to convert cold copper and soft steel ingots into thick sided tubes that are afterward drawn out. The point, A, is provided with three longitudinal grooves, enlarged from the point to the base, and with rounded sides, so as to displace and face back the metal without cutting it, and designed likewise for the passage of the petroleum for lubricating the point when ingots of copper are thus treated in a cold state. The velocity of the tool at the circumference is then but about three inches per second, although it is very rapid (40 feet per second) when hot steel ingots are being pierced without a possibility of oiling the point. The advance of the tool in this case is about five feet per second.

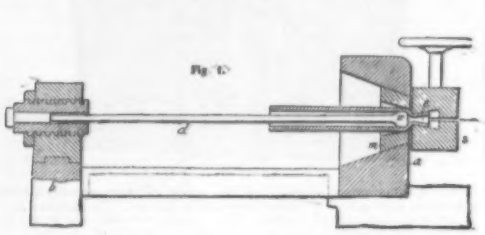
Figs. 13, 14, and 15 also represent, of half actual size, a mandrel designed for converting cold copper ingots into tubes. The point of this is provided with a center punch that permits of more surely grinding the mandrel, especially if a guide hole be formed by means of an ordinary drill, as seen at B'.

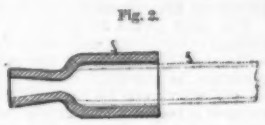
When it is desired to convert a hot steel ingot into a tube, it is necessary, as we have said, to give the mandrel a very rapid rotary motion—say from 12,000 to 18,000 revolutions per minute. Mr. Robertson succeeds in doing this by means of two rollers, S and S' (Figs. 16 and 17), which revolve between them and the mandrel, A, thrust by the piston, F, against the ingot fastened in the cylindrical jaws of the draw plate, *c c'*. The gearing in E E' permits of making S and S' approach each other or recede, and of thus stopping the revolution of the mandrel at will. The two parts of the jaws *c c'* are capable of locking up the ingot, B (Fig. 18), or of freeing it (Fig. 19), according as the lever c^5 occupies the position shown in Fig. 20 or the position, *a b*, under the action of the winch, H. The process indicated in Figs. 21 and 22 of drawing out thick tubes, B, consists in submitting the external surface of the tube to the action of a series of screw threads, c^3 c^3 c^3, of different pitches, in the draw plate, *c*, which revolves in a direction contrary to that of the mandrel, A. The draw plate represented in these figures is more especially adapted for drawing out copper tubes. Conversely, as shown in Figs. 23 and 24, the mandrel itself may be provided with threads, A^3, the revolving draw plate, *c*, bearing upon the tube to be drawn out only through the bosses, B^3, which facilitate its lubrication; or we may cause a helicoidal drawing to act both on the interior and exterior of the tube (Figs. 25 and 26).

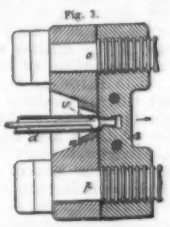
A variant of this process may be explained without figures. It consists in drawing out the tube upon its mandrel through the action of two rollers having circular grooves. The mandrel, which makes about fifty revolutions per minute, is lubricated with soap water.

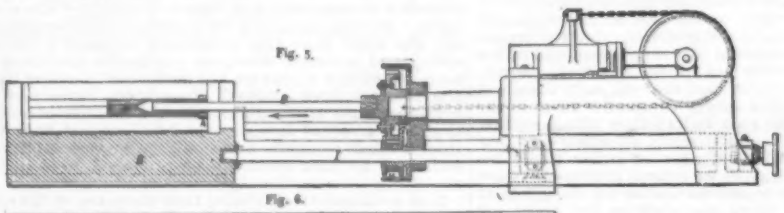
In Messrs. Reinhard & Max Mannesmann's process, the seamless tubes are obtained by rolling solid bars. As shown in Fig. 27, the bar, B, is held between two cones, A*a*, revolving in the same direction and the axes of which point in opposite directions in parallel planes. The converging sides of the cones between which the bar is held draw out the metal at its periphery in such a way as to gradually make it assume the form of a tube, the beginning of which is seen at *b*. When the finished tube comes from the roller, as shown in Fig. 28, there remains a blank, B, hollowed out at b^3, through the pressure of the cones.

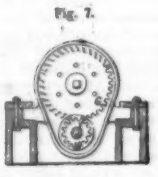
The cones are nearly always hollow helices with pitches increasing from the point to the base, so as to

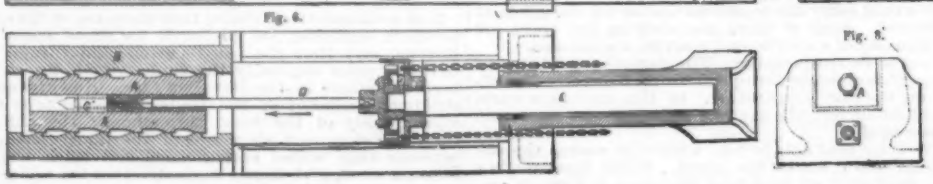


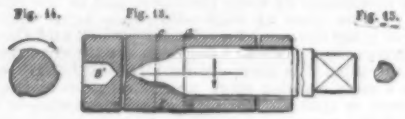


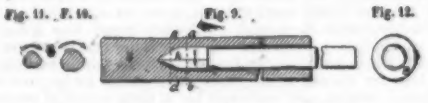


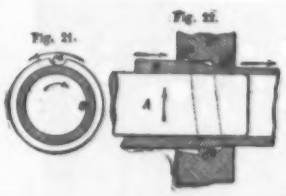


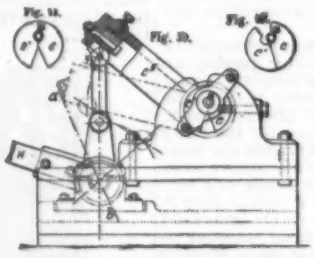


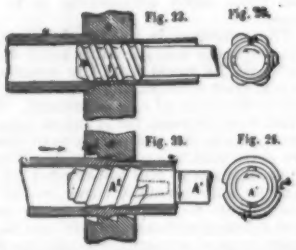


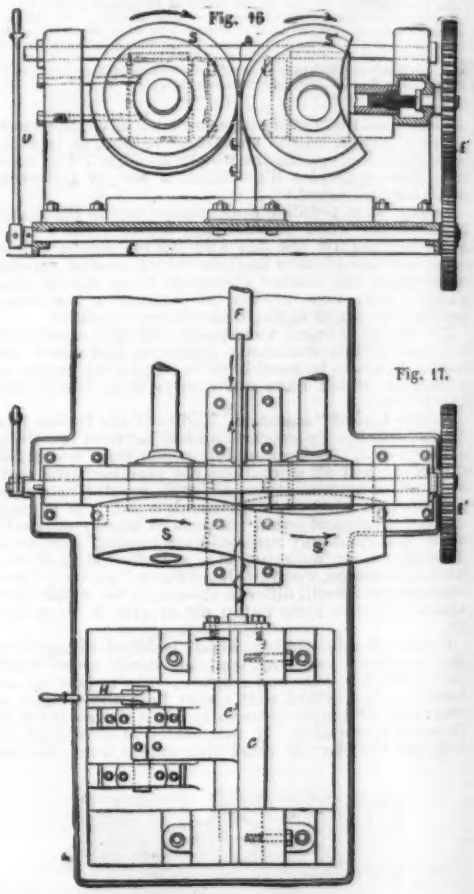












FIGS. 1 TO 4.—THE FLOTOW & LEIDIG PROCESS. FIGS. 5 TO 26.—THE ROBERTSON PROCESS.

APPARATUS FOR THE MANUFACTURE OF SEAMLESS TUBES.

draw out the surface of the bar progressively in measure as it advances between the cones.

If it is desired to avoid the blank shown in Fig. 28, it will suffice to push the tube submitted to drawing over a mandrel, D (Fig. 29), which revolves in a bearing, E (Fig. 30).

For softer alloys, which may be rolled in a nearly cold state, a conical mandrel is employed (M, Fig. 31), and this, if need be, can be kept cool by a stream of water, and serve to increase the diameter of a tube already formed. This mandrel terminates in a grooved point, and can, as shown in Figs. 32 and 33, revolve in the same direction as the ingot, or the opposite, according as it is desired to retard or hasten the drawing around the point of the mandrel.

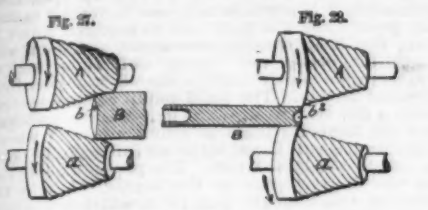
The process by means of which the tubes shown in Fig. 34 are obtained is founded on the principle that an ingot rolled diagonally between two cones (A and *a*, Fig. 35), revolving in opposite directions, undergoes at the bearing point distortions that are distributed over the triangular wheels, *c c*, which cause within the ingot molecular stresses, *c'*, whose resultant tends to distend its fibers all around its axis, in measure as it revolves between the cones. The tubes thus formed are smooth within. Their fibers are not broken, but lengthened out spirally around their axis.

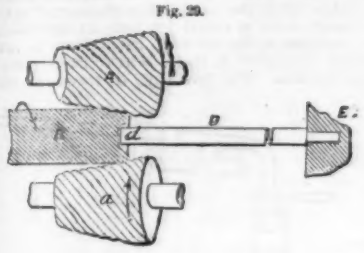
The apparatus represented in Fig. 36 serves for manufacturing copper tubes of uniform thickness, and of a diameter greater than that of the ingot. The point of the mandrel penetrates the ingot very easily without heating it much. In a new variant of their process, Messrs. Mannesmann substitute mushroom shaped rollers, A *a* (Fig. 37) for the cones. The intersection of the vertical planes passing through the axes of rotation and through the apices of the rollers is situated in the vertical plane passing through the axis of the ingot, D, and mandrel, E. Moreover, the angle, *e*, of the mandrel is a little more open than that of the rolling generatrices of the mushroom shaped rollers, so that the lamination compresses and reduces the thickness of the sides of the tube on the mandrel, while its diameter at the same time increases. From Fig. 38 will be seen how a tube may be made by means of two successive operations, one of them preparatory, and consisting in tubing the axis of the ingot by the diagonal rolling of the plates, F *f*, and the other a finishing operation, consisting in widening the tube on the mandrel, E. In this case, the rollers, A *a*, may be given a velocity such as to make the mandreled part of the tube rotate more rapidly than that part of the ingot submitted to the action of the plates, F *f*.

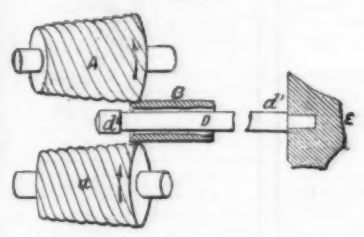
Figs. 39 to 44 show how it is possible to make a tube directly with but a single pair of rollers, G *g*.

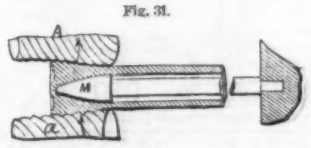
Before approaching the mandrel, E, as shown in Fig. 40, the ingot (Fig. 39), held between the converging generatrices of G *g*, undergoes a preparation that reduces its diameter and hollows its extremity at *d'* (Fig. 40), so that it can favorably meet the point of the mandrel in passing from the converging to the diverging generatrices of the rollers. The tubular part of the ingot is then, as shown in Fig. 41, pushed along and compressed on the mandrel through the gradual action of G *g*, and converted into a thin sided tube, until the posterior end of the ingot leaves the rollers.

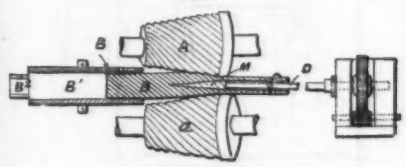
When the entire manufacture of the tube is effected by means of a single pair of cones, it is necessary that the torsion given to the ingot by the converging generatrices during the first part of the operation (Figs. 39 and 40) shall not be destroyed during the widening and calibrating (Figs. 41, 42, and 44), because such torsion, which winds the fibers spirally around its axis, considerably reduces its resistance to internal pressure. To this effect, the rollers are given a profile and inclination such that the vertical planes passing through their summits, situated (as shown in Fig. 42) at different levels, intersect each other in the vertical plane of the axis of the tube. The tube thus rolls without torsion between the divergent generatrices.—*Revue Industrielle.*

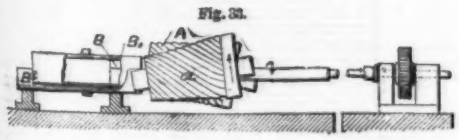


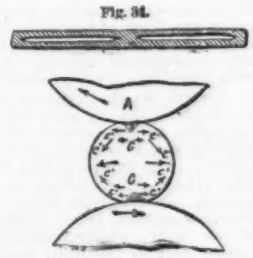


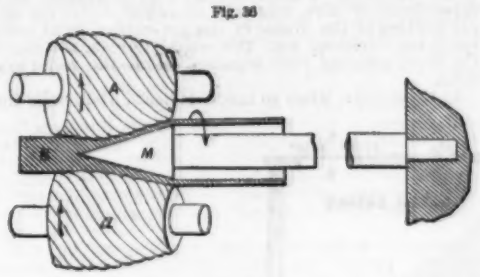


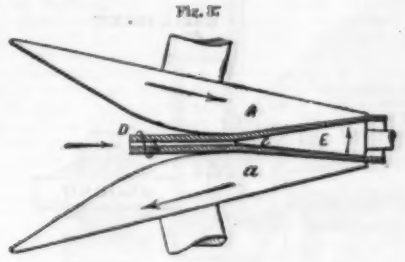


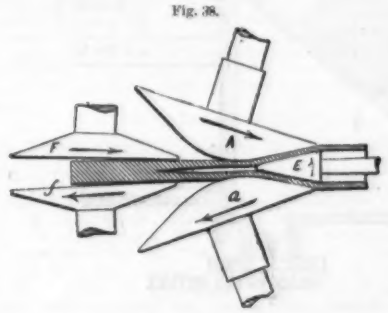


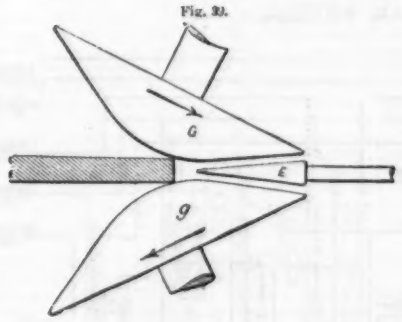


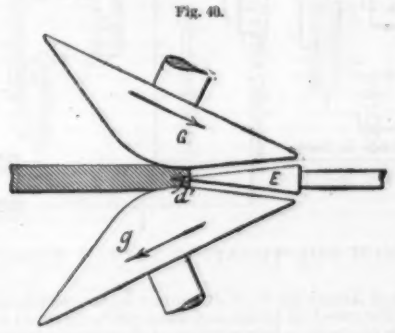


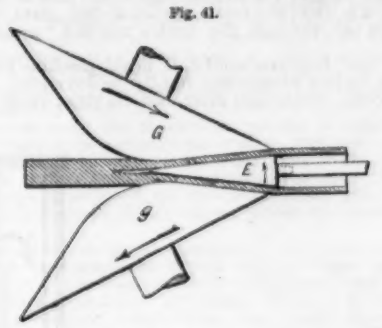


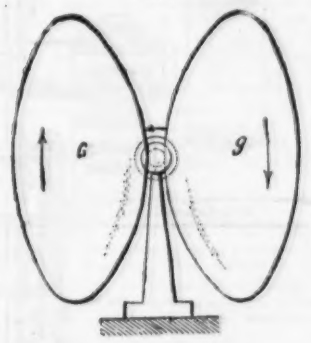


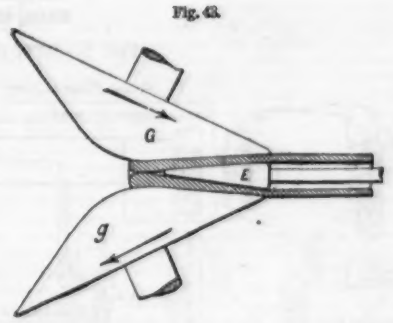


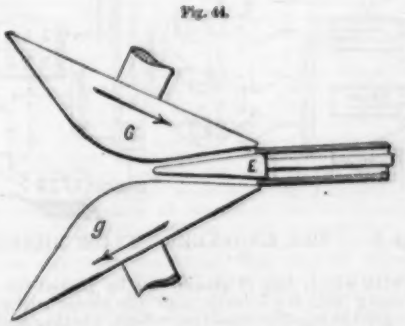












MANNESMANN'S APPARATUS FOR MANUFACTURING SEAMLESS TUBES.

TROUTBECK PARK GREEN SLATE.

THE special advantages claimed for these slates are durability, color, and thin cleavage. It is stated that they are from strata composed of volcanic ash, and are therefore more durable than the Welsh slates quarried from ordinary sedimentary deposits; the color, a soft sea green, either light or dark, said to withstand all climatic influences, while the thin cleavage renders it possible to have a strong roof without corresponding increase in weight. One ton of the best slate is said to cover about 27 superficial square yards. These quarries have been worked about 100 years, and it is estimated that at the present time they turn out from 8,000 to 10,000 tons of slates per annum, valued at about $175,000.

A. CAVAZZI (*Gazzetta Chimica Italiana*), in studying the reduction of potassium nitrate by various substances, has found that a mixture of equal parts of the nitrate and sodium hypophosphite detonates violently when heated to about the fusing point of the mixture. The experiment should be made on small quantities only, and while other proportions yield an explosive mixture, those mentioned are the best.

RITCHIE'S STEAM WHIZZER.

OUR illustration, Fig. 1, is self-explanatory. The principle of the machine, says the *Engineer*, is that it subjects the grain in the revolving cage to the action of steam, and the effect of the steam pressure passed through the wheat renders musty grain quite fresh, and removes all the smell common to Indian wheats. The mode in which this is done will be clear from our illustration to any engineer. The engraving is a section through the machine. The driving shaft carries a revolving wire cone inside on an iron casing. The wheat is fed in at the inlet and is carried into the machine by means of a short conveyor. The cage is made to revolve rapidly, which causes the grain to spread itself in a thin sheet over the interior of the cone; it thus finds its way from the apex or small end of the conical cage to the base or larger end, and is there delivered against a dash plate, where it drops out through the orifice marked "grain outlet."

The vast importance of this novel machine for preparing Indian wheats can hardly be overrated. It is an efficient centrifugal drier, but its great value is the ease with which jets of steam can be passed through the casing into the interior, and the steam rushing in impinges the rapidly revolving wheat, heating and dislodging all the adhering impurities, and imparting a freshness to the grain which greatly enhances its value. This little machine has done much to make Indian wheats fit for being reduced into flour. It is the invention of Mr. Ritchie, of the Derby Road Mills, Liverpool, and is manufactured at the Boundary Street engine works in that city. From the whizzer the wheat passes to the smut machine, where it is first subjected to the action of a strong separator, which removes light grain, seeds, etc. From the smutter the grain is spouted, or elevated, to the wheat polisher, where it is scoured. The wheat after leaving the polisher passes over the magnetic separator, which removes the nails, wire, and iron so plentiful in Indian wheats. The wheat has now gone through the cleaning process and is ready for the second part, viz., reduction and dressing into flour. The cleaned wheat is spouted from the bin to the wheat grader.

From the grader, the large wheat passing over the tail of the reel drops to the top rolls of the first break roller mill, while the small grains as they come through the reel fall to the bottom rolls. In our flow sheet it will be seen that the grain, after passing through the first break rolls, it is treated on a scalper, where the crease dirt is dressed out. The tailings of the scalper pass to the second break rolls, where the grain is considerably broken, and falls to an air separating scalper.

We reproduce in our flow sheet an air separating scalper, similar to the circulating pneumatic mineral sizers used during the last half century in the pottery works in Staffordshire. The grain, as it escapes from the second break rollers, is disintegrated sufficiently to be in the form of bran, middlings, flour, etc., and the air draught is drawn through the material as it is delivered in a thin, even stream by the feed roll into the space below, the heavy particles fall into the first division and drop to the third break rolls, the next heavier is sucked by the air into the second chamber and fall to the fourth break rolls, while the light branny pieces are drawn over to the last division and fall to the fifth break rolls. A dickey grader, with three sheetz of wire, might be arranged under the upper portion of the frame of the air scalper, right over the three divisions, and this would obviate the use of the three scalping reels common to all the roller systems.

In these days, when so much is heard about the im-

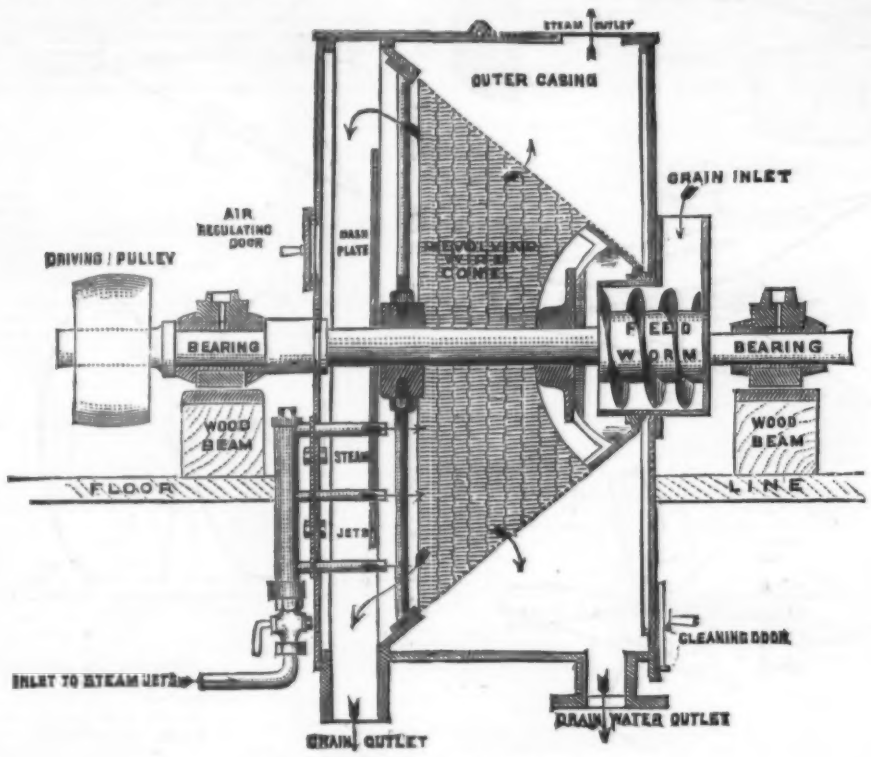


FIG. 1.—RITCHIE'S STEAM WHIZZER.

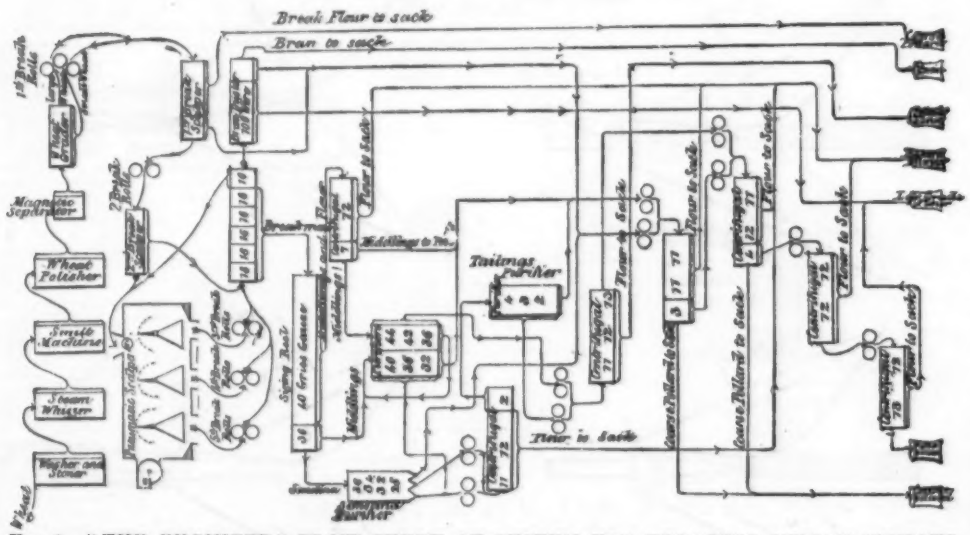


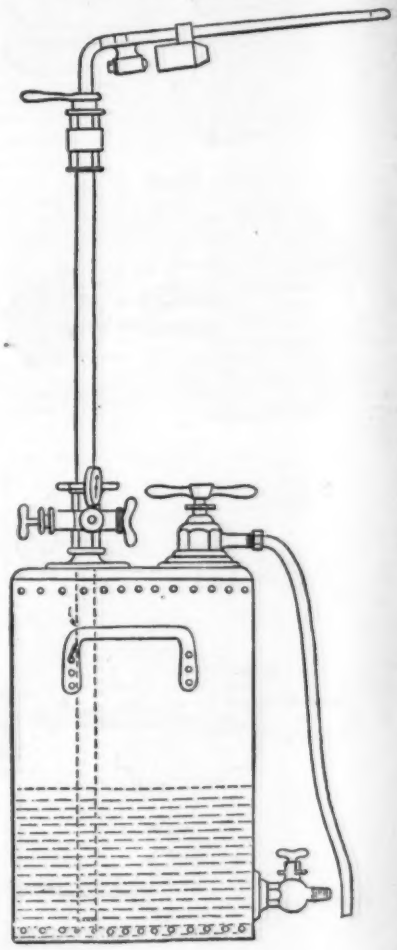
FIG. 2.—"THE ENGINEER" FLOW SHEET OF SYSTEM FOR TREATING INDIAN WHEATS.

ports of American flour, it cannot be too widely known that the sweetest bread and most nutty flavored is that which contains a fair mixture of flour made from English wheats. The following is a summary of the sizes, speeds, and prices of the machines used in our flow sheet to produce 500 sacks of flour per week:

Description.	Length.	Diameter.	Speeds.	Price each.	Price of number used.
	ft. in.	ft. in.		£	£
1 Wheat washer and stoner	30 0	5 6	70	75	75
1 Steam whizzer	4 0	6 0	350	70	70
1 Smutter	6 0	....	550	45	45
1 Wheat polisher	7 0	....	500	90	90
1 Magnetic separator	2 0	....	40	8	8
1 Grader	5 0	2 0	40	25	25
3 Three-high roller mills	1 6	0 10	240 & 300	48	144
2 Scalpers	8 0	2 6	30	20	40
1 Air scalper	12 0	....	200	70	70
2 Reels	16 0	2 6	30	28	56
1 Semolina purifier	10 0	....	500	40	40
3 Middlings purifiers	10 0	....	550	40	120
3 Three-high roller mills	1 6	0 10	340 & 400	45	135
Shafting, pulleys, belts, elevators, spouting, and all other accessories					375
Price of the complete 500 sack mill					1,200

THE WELLS LIGHT.

THE accompanying sectional engraving represents a new oil lamp—Wallwork & Wells patent—which is being introduced by Messrs. A. C. Wells & Co. Messrs. Wallwork & Wells have, we understand, been experimenting upon this lamp for the last five years, and their object has been to produce a powerful portable light suitable for railways, engineering and shipbuilding works, collieries, for contractors' use, etc., and the "Wells light" would certainly seem to be a very efficient lamp for the requirements above named. The *Engineer* says the light produced is similar to the well known "Lucigen," but in its general construction and principle the "Wells" is entirely different from the "Lucigen." Perhaps the essential difference is that it requires no outside motive power, while, as already intimated, it is portable and can be readily carried to any point where the light may be required. As will be seen, the lamp consists of a closed oil cistern with a hand air pump, and rising out of a tank is a delivery pipe which conveys the oil to a specially constructed burner. The hand pump compresses the air with a few strokes up to 25 lb., which is sufficient to run the lamp for three or four hours, and when the pressure has run down, oil or air can again be pumped in at the will of the user. The pressure forces the oil up the delivery pipe to the burner, where it passes through two wrought iron pipes which are enveloped in the flame, and the oil is thus converted into vapor which issues from a small jet hole at the back of the burner, picking up its air with great force as it travels. The flame produced is quite white, and there is perfect combustion. The pressure to force the oil to the



burner can be obtained in various other ways besides the one shown in the form of lamp illustrated, and the firm own patents for connecting these lamps to towns water pressure or overhead cisterns. For permanent installation this furnishes a very convenient method. The water is forced by its pressure into the closed lamp body in which is the oil, and this drives the oil up the delivery pipe to the burner. When the oil is all pushed out, the water is simply withdrawn and oil again substituted. The lamps which the firm are at present making give a light of 2,000 to 2,500 nominal candle power, and we understand that the consumption of oil does not amount to more than 1d. per 1,000 candle power per hour, which represents practically almost the entire cost of the light, as there is no outside expense for producing a continuous supply of steam or compressed air beyond, of course, the labor required for recharging the lamp.

FINISHING PHOTOGRAPHS.*

HAVING been requested to furnish a short paper for this evening, in harmony with our annual show of work, and the text having been suggested, "Finishing Photographs," I will endeavor in a few words to bring under your notice the different processes that a photograph has to undergo after it has surmounted the troubles of its chemical birth, and is, so to say, fairly launched to either founder in the waters of oblivion or remain a pleasure and a joy as long as its chemical constitution will permit.

We will take up the photograph after its final washing, and the first operation it has to undergo is drying and flattening out; the trouble of doing this is somewhat dependent on the paper itself. Highly albumenized paper gives an increase of trouble in proportion to its gloss. If dried between sheets of blotting paper under pressure, or on shallow frames covered with cal-

* A communication to the Photographic Club.

ico, it is presented in a fairly flat condition, but if hung up to dry in a current of air, there is a good deal of objectionable curliness that requires ironing out face down on a piece of stout, fine felt, with an ordinary flat iron, or it may be laid face down on a slab of glass, and firmly scraped on the back with some smooth instrument, such as a bone paper knife, or, as some prefer, rolling them face outward on a smooth round rod and leaving them so for an hour or two. By using any of these plans, the tendency to curl is much lessened.

Then comes the trimming. Three distinctly different ways are in vogue, namely, with the scissors, the knife, or the wheel cutter. It must be assumed that the prints have been in some way marked to facilitate this operation by having an opaque line drawn round them, or the margin painted out, a necessary condition if an opaque cutting shape is used; if a glass one is in favor, the lines, although useful, are not so imperative. A glass table, or something equivalent, is required to support the prints during cutting by knife or wheel. Glass, on the whole, is perhaps more in favor than anything else. Complaints may be made that the knife requires frequent sharpening, but this is soon done, and unless a good deal of unnecessary pressure is used, is not a very valid objection. The clean, smooth edge obtained is its great recommendation. A piece of good, hard, stout cardboard answers nicely when only a few prints have to be trimmed; a smooth, fine grained wood has also its advocates. The wheel cutter is an excellent instrument, especially for cutting curved lines; it seldom, or never, requires sharpening, but the cut is not quite so clean as with a good knife. The shape of the knife has much to do with its effectiveness. A freshly broken penknife blade will cut excellently well, which indicates the knife should be sharp pointed. The shape or rule must have its edge perfectly flat, so that it will press firmly and equally along the print, close to the cutter; if it does not, the probability is that the paper will be puckered up and torn as the knife is drawn along, however sharp it may be. A perfectly smooth, clean cut must be made, whatever means are used to effect it.

After trimming, the print is ready for mounting, or hot pressing, as the case may be. With hot pressing, prints are intended for the album without mounting, which indicates that the touching up should be previously done, as the gloss imparted makes the retouching less noticeable, and there is no risk of crumpling the print.

The mounting is a very important process, both as regards the existence and beauty of the print. Only such mountants should be used that are known to be perfectly innocuous. Starch, gum arabic, and glue are the most popular substances. I believe glue or gelatine is preferred by professional mounters, and starch by those who work on a smaller scale; each has its recommendations. With glue, the print once laid down must there remain; no shifting about to adjust it can be done. With starch or gum this is easy, and starch is especially cleanly in use, having no gloss; if a little gets on the mount, it is not noticeable. Mixtures of these substances have also met with favor, especially a compound of starch and gelatine, which is supposed to combine the advantages of both substances, and probably does. Whatever mountant is used, it is an imperative condition that it is free from acid from fermentation, or otherwise. A mucilage of gum arabic has been and is largely used, perhaps because it is so convenient, being used for numerous other purposes than mounting photographs, and is generally at hand; properly made, it keeps well and retains its adhesiveness. Gum tragacanth and quince seeds both supply excellent mountants, but when the first named substances are so easily obtained, it is scarcely worth while to seek others.

The mounts next must receive attention. There are two classes of them—one in which the prints are in optical contact with the glass, and the other not. It goes without saying that of whatever material the mounts are made they must be free from all deleterious matter. If cardboard is used, a lithographed tint undoubtedly in some measure protects the print from anything wrong in the boards, but, for my own part, I infinitely prefer India paper, between the photograph and the mount, which, in my opinion, not only improves the appearance, but conduces to the permanence of the print.

The marginal tint, whether lithographed or India paper, has the effect of binding the composition together, as lines drawn round it will when light and dark parts of the subject end abrubtly at the edges of the print. Some prefer a margin unbroken by lines, or tint, or ornamentation of any kind; this is, however, a pure matter of taste or artistic feeling. We are seldom wrong if we incline to simplicity. I think the highly ornamental borders we sometimes see are very objectionable and damaging to the effect of the photograph. In addition to the tint, an indentation round, called the plate mark, is oftentimes an excellent finish, although it is open to the objection of being a sham, the plate mark really being a result in printing an engraving, the pressure used to impress the image impressing also the edge of the plate. It does not, however, mislead any one, is an innocent deception, and improves the work.

Mounting prints in optical contact with glass is a favorite way with many; it gives a richness and quality to a photograph that nothing else will, and tends to its preservation. The green shade sometimes seen is owing to unsuitable glass being used; a pure white, or glass *inclined* to pinkness, should be selected. If the glass is right, the color of the mounted print leaves nothing to be desired. It goes without saying that the mountant must be clear and free from dirt. About a quarter of an ounce of good gelatine is dissolved in half a pint of water; the exact quantity is not material. When it is quite dissolved and hot, immerse the print for a minute or so in a sufficiently large dish; slip under it the glass which has been cleaned and warmed, and lift both up carefully together, and with a squeegee go over the back of the print to expel all air bubbles; sponge the face of the glass with a moist, warm sponge and set aside to dry. If it has been properly done, it will present a perfectly unbroken surface free from markings of any kind; it need not be said that grit or air bubbles are fatal to good effect.

A very effective and popular method of mounting is the use of cut-out mounts, which has somewhat the effect of framing, but adds to the weight and bulk of the picture. When shapes other than rectilinear are chosen for the subject, cut-out mounts are often the most artistic and effective method of doing it. Circular, oval, or dome shapes are better masked off on the negatives than trimmed to them afterward, unless cut-out mounts are intended to be used, the margin being left white or tinted according to circumstances. Most photographs are touched after mounting, defects made good, and too bright spots reduced in intensity. After this, the application of an enamel cerate will not only brighten up, but preserve the print. I have great faith in the preservative powers of resinous or waxy matters applied to the finished work; in fact, any application that will, without injury to appearance or degradation of the lights, protect the picture from decay, is to be commended. In small work, such as *cartes de visite* and cabinets—portrait subjects especially—enameling by giving them a coat of collodion and gelatine will not only improve their appearance, but wonderfully add to their atmosphere-resisting capabilities. I have prints by me, taken from the usual batches and enameled, that were made sixteen years ago, and have remained as bright and pure as when first done. Also others mounted in the ordinary way with gum and starch, with a final rub of cerate, that have remained without change two or three and twenty years. Of course, the polished surface of the enamel is out of place on large work, but with small it offers many advantages. The various ways of mounting on blocks, panels, etc., are varied, but require no particular notice.

The final operation of framing is now to be thought of, and much depends on individual fancy. A light frame is, perhaps (of whatever material it may be made), most suitable for a photograph with a margin, a dark picture framed close up will bear a heavier frame; but whatever frame is used, simplicity should be the governing idea. The glass should be carefully pasted to the frame with strips of paper, and the back well papered over, care being taken to remove any shreds or dust from between the picture and the glass that may have accidentally found their way to the front, which form a considerable eyesore and vexation when the framing has been completed; it is also most necessary to see that the picture is square in the frame, and that a proper amount of margin has been left around it. A little mistake in these matters is very annoying and damaging to the general effect. I think I have now touched on most of the different phases in the finishing of a photograph, from the time it leaves the washing trays until it either becomes a warning of something to be avoided in future or a source of satisfaction and pleasure to the possessor and his friends, at the same time suggestive of topics that may lead to profitable discussions.—*Edward Dunmore, in Br. Jour. of Photo.*

THE MONUMENTAL USES OF BRONZE.*

By J. STARKIE GARDNER, F.S.S., F.G.S.

No substance is so superlatively fitted for monumental use as bronze; there is a sense of dignity, weight, and value about it when used in considerable masses possessed by no other material; it defies the ravages of time, and baffles the iconoclast who would deface it. Take it all in all, it is more enduring than any other thing on earth, for, though surpassed in some of its properties by gold, silver, and platinum, the great intrinsic value of the precious metals has in all ages proved the destruction of works in which they are largely present. In contemplating great works of bronze, this vast and limitless enduring capacity of the material insensibly asserts itself, investing them with a solemnity and awakening feelings which it must ever be the highest aim of memorials to the dead to produce. Mountain chains and coast lines of even the hardest syenites and porphyries present scenes of ruin, with aiguilles and rocky islets to mark the crumbling and disintegrating action of sun, frost, rain, or surf; but the external elements would work almost in vain on the contours of a world cast in bronze.

Bronze is an alloy of two or more metals in which copper predominates. The subject of alloys is to be treated so exhaustively by my friend Professor Roberts-Austen before the society in a few weeks hence, that I shall not presume to allude to it now. I cannot refrain, however, from congratulating ourselves that metallurgical secrets of profound interest, and of the highest importance to us to know, should be revealed for the first time to this society by the most competent living authority. The results, among others, of forming these alloys, is to modify the fiery red of copper through every shade to the yellow of pale gold or the pure white of silver. Further, age and varying exposure clothes some of them with a skin or *patina* ranging from vivid blue-green to olive, and from jet black to rusty red. This favored metal bronze! These exquisite rusts, instead of eating into its heart like the rust of iron, cover it with an impermeable sheath, and preserve it from decay. It is almost superfluous to say that all these natural tones of color can be imitated artificially. The Japanese excel in the art, and blend and cloud them together, enriching the palette of the worker in bronze with colors, such as coral red, which almost cease, without ceasing, to be metallic. We may also, if we please, without departing from immemorial precedent, obtain increased richness by gilding, plating, enameling, nielloing, and damascening.

But this far from exhausts the capabilities of bronze, for in the matter of form it is even more Protean. Everything possible to the sculptor's art is possible to bronze. It can be fused and cast into moulds of every intricate shape and for every purpose. Or it may be rolled and drawn and hammered and beaten into every kind of utensil, from the familiar copper of the kitchen to the most delicate object that the art of the goldsmith can produce. Remarkable hoards, discovered from time to time, show that bronze was all in all to our prehistoric ancestors; it served for weapons, tools, utensils, and ornament. When architecture began, it entered largely into the construction and embellishment of buildings. Art employed it for statues, candelabra, tripods, money and medals; solemn records, laws, and treaties were engraved on it. In peace its sonorous tones record the flight of time and summon us to worship; in war the clashing cymbals, blare of bugle, and trumpets' bray have played no mean part. Of late we have added the "death-dealing roar" of cannon and the life-saving croak of the siren, or foghorn, to the voices of our useful servant, bronze or brass.

It would be interesting to track the metals whose properties when blended are so diverse to mother earth, and I should like to treat that subject *au fond*. To explore the "country" rock with its lodes and veins, and these with their faults and upthrows and downthrows, "checks" and "troubles," from the stream works of the surface to the mines so many fathoms deep that I have boiled eggs in the water as it issued from the rock. The story of the mine is as full of mystery and romance as the story of the sea. People embark their all, either to find their capital returned one thousand times over, as in the case of the Devon Consolidated, or to see their money utterly and hopelessly sunk in barren adits and shafts. The beauty and variety of the ores of copper, as kindly exhibited to-night by Mr. Gregory, portend the lovely contrasts to be obtained from them in their manufactured state. But lovely as are these blue and green carbonates, these red and black oxides, these gray, purple, and yellow sulphides, they are without compunction mixed, and calcined, and smelted again and again, until the regulus or residue is sufficiently rich, when it is refined with carbon and run into ingots. I ought to explain the rudiments of this manufacture, if the bronze mechanism of the clock did not warn me not to linger, for we cannot really talk profitably on a subject unless we know all about it from the beginning.

Though an artificial compound, and not a natural product, the history of bronze has no beginning, and tradition is even silent as to the continent from which its use first spread over the earth. We only know that Assyrian bronzes exist which were made more than 2,000 years before the Christian era, while the Egyptians were fashioning their lintels and sarcophagi with tools of bronze in the sixth dynasty. The most ancient records of China, under the Chang dynasty, 1766 B. C., show the art of working in bronze in full perfection. Dr. John Evans says that our bronze age ceased in the fifth or fourth century B. C., but that no beginning can be assigned to it, though the perfection and complexity of the objects discovered show that the art had endured here for many centuries. If Sir John Lubbock is right, our barbarous isle was resorted to for tin by the Phœnicians 1200 or 1500 years B. C. The use of bronze came in everywhere with dawning civilization, and immeasurably antedates alike history and tradition.

The history of bronze working as a fine art is equally lost in the remoteness of its antiquity, but the beauty of the material soon led, we can well imagine, to the ornamentation of the weapons and utensils into which it was fashioned. Perhaps the desire to distinguish one's own property, or to exalt the property and surroundings of a chieftain, may have been the humble beginning whence art sprang, but arrangements in nicks and notches formed probably its elementary stage. Figures of animals, so far as we know anything about it, would seem to precede those of men; it is safe to conclude that the image bearing the name of an Assyrian king, who lived either 2100 or 2200 years before Christ, does not represent anywhere near the infancy of bronze, even as an art. The highest aim and accomplishment of art is the representation of the human form, for we are told God made man in his own image, and therefore man in his highest type is "the roof and crown of things," and nothing more beautiful is to be imagined. The apogee of this art about coincides with the introduction of actual portraiture in bronze, as seen in the bust of Pericles by Cresilas, shortly before the time of Phidias. The figures of Osiris of the Egyptians and the angels of the Hebrews were rather objects connected with religious worship than commemorative. It is recorded, however, that Romulus had his statue set up in bronze, crowned by victory, and in a chariot with four horses, while another bronze statue was erected to Horatius Cocles, an equestrian statue to Clelius, and the goods confiscated from Spurius Cassius served for a statue to Ceres. The use of bronze in Italy preceded its use in Greece, and we may well imagine its relative importance, since the guild of bronze workers stood third under Numa Pompilius. Another most suggestive item of history is the record that after the war with the Volsinii, 2,000 statues of bronze were carried to Rome. According to Pausanias, the art of statuary founding was only introduced into Greece in the 42d Olympiad (546 B. C.), and if so, it must have spread with a speed only paralleled by the spread of railways, for the Romans found about 3,000 statues at Olympia, the same at Rhodes, also at Delphi; 3,000 remained at Athens after its first spoliation by the Romans, and, singularly enough, Mummius took the same number from Corinth to Rome. Once more, 3,000 were collected by Scaurus and used to decorate a theater. Some of these, like the Minerva of Phidias, 70 feet high, crowning the Acropolis, and made from the spoils of Marathon, or the Jupiter of Tarentum by Lysippus, 60 feet high, were colossal. An Apollo taken from the Samnites and set up in Rome could be seen from the Alban hills, and the statue of Nero was 115 feet high. All these were bronze, like the still more famous Colossus of Rhodes, which was 105 feet high, and weighed 720,000 pounds. Only one of the gigantic antique bronze statues has escaped destruction, that of Theodosius at Bartella. We must quit the subject, however. In reading this paper, I am obliged to pass over section after section of our subject until only a small sub-section of it is left. Suffice it to say that the originals of almost all the finest antique marble statuary preserved are known or believed to have been in bronze. The immense value of the material in the days when they were smashing and reducing marble statuary to the mutilated condition in which we are but too glad to recover it, led to the almost complete disappearance of large objects in bronze, but we have the Sleeping Fawn of Herculaneum, the Wrestlers of Portici, the Boy with the Thorn of Pompeii, the Hercules of the Capitol, the Septimus Severus of the Barberini Palace, and the colossal equestrian Marcus Aurelius, which was spared, as it was believed, to represent a Christian emperor. Of small statues the quantity discovered is innumerable.

There is one point connected with antique statuary that we cannot pass over, and that is its color and treatment, for this is suggestive of endless future possibilities. It is doubtful whether the metal was stained or allowed to oxidize at all, and whether it was not as-

* A paper recently read before the Society of Arts, London.

similated as much as possible to the color of the sunburnt athletes it represented. We still speak of being bronzed by the sun, and this, like many another familiar expression, may have been handed down from remote times. Plutarch mentions a dying Jocasta to which a mortal pallor was given by a silvery bronze, and Pliny a bronze Athamas red with shame. Callistratus records that Praxiteles gave a natural color to bronze statues of Cupid and Bacchus, and a bass-relief representing a battle between Porus and Alexander is said to have equaled painting in the brilliancy of its colors. A life-like expression was given by glass or marble eyes, and sometimes head-dresses, etc., were in gold and silver. The statue of Hercules, found recently in Rome and now in the Vatican, was gilt, but probably gilding belongs to a late period, when art was in its decadence. The present appearance, which we admire in Greek and Roman bronze statuary, is due to the conversion of the surface copper into carbonate by contact with carbonic acid contained in rain water, particularly when it has percolated through volcanic ash. The commonest color is green, but blue, light bluish green, and red are also met with. I wish I could introduce some most valuable remarks sent me by my friend Dr. Johnston Lavis, of Naples, as to how these have, in some cases, been coated with malachite, in others by bright blue azurite, or the chalky bluish aurichalcite, and the red crystalline cuprite. The smooth, hard, dark, polished surface more characteristic of Herculaneum bronzes is due to their having been enveloped in a compact and impermeable matrix.

We now have to pass over subjects wholesale. The paneling, and even paving, of Greek and Etruscan tombs and treasuries with bronze; the bronze produced under the influence of Byzantine art, including the bronze church doors, about 200 examples of which still exist in Italy; the whole subject of bronzes of the Renaissance, rendered so illustrious by Andrea Pisano, Donatello, Ghiberti, Verrochio, and Cellini. These, as well as Flemish, German, and French bronzes, were ably, but all too briefly, treated by my friend George H. Birch in his Cantor lectures, of which I have made the freest use. Having set aside branches of our subject, enough for several separate papers—for everything in bronze by which the memory of a person or event is perpetuated is a monument—we come to the only section which time at all permits us to deal with, the use of bronze for sepulchral monuments or tombs. These are mainly of two kinds, those in relief and the flat, incised slabs, called brasses. In England we have not more than a dozen of the former and about 4,000 of the latter still preserved. The most important of the bronze tombs in relief are in Westminster Abbey, and we will rapidly pass them in review.

The earliest is that of Queen Eleanor, who died *en route* to Scotland in 1290, when her body was embalmed with spices. As appears customary in those days, the heart was buried separately in the church of the Friars Predicants in London, and the bowels interred at Lincoln, under a brass effigy similar to that at Westminster. The effigy, in gilt bronze, is in simple attire, falling in not ungraceful folds, while the expression is one of sweetness and composure. An unjeweled crown is worn, but the cushion and slab are diapered all over with the arms of Castille and Leon. The small canopy above the head has a scaled roof and well-modeled angel head corbels, and there are at the feet two lions. A part of the inscription is visible, "Ici gist Alianor jadis Reyne de Engletere: femme all rey Edeward fiz—"

The effigy of Henry III. is similar, but much stiffer, and the lions and canopy have disappeared. It rests too high up to see the details, but the head is said to have much of the simple majesty of the Greek school. The heart is buried at Fontrevault. The feet and cushions are diapered all over with lions. Henry died in 1272, and his is the earliest bronze effigy in England.

On the south side is Richard II. and his queen, in more sumptuous robes, embroidered with rising suns, white harts, and peas cods, with jeweled hem. These, like all the other royal effigies, rest on a slab cased in brass, with chamfered edges, on which inscriptions are engraved; holes indicate that some ornament had been removed. It is difficult to see the queen. The canopy is double and still rich, though much has been stolen; the face is evidently a fine portrait, though somewhat coarse, and no longer representing a beautiful and ingenuous countenance. It bears a small forked beard. The head is uncrowned, with the hair bound by a fillet; the feet are almost hidden by drapery. All the figures of saints and angels, the enamel shields, the hands, the two lions, eagle and leopard on which the feet rested, in fact everything portable, has been purloined. The bronze work, made during the king's life, 1395–97, cost £400.

Next this is the tomb of Edward III., died 1377, which has suffered far less spoliation. On each side of the effigy is some architectural metal work supporting a richly wrought canopy, in the niches of which are angels, cast from one mould, while other enrichments have evidently disappeared. The figure is tall and thin, the head bare, with long flowing hair and beard parted down the middle, and mustache. The features give little indication of the heroism displayed at Cressy. The garments are plain, with engraved jewel pattern borders; plate armor peeps from beneath the sleeves, and covers the wrists. The shoes are thin, pointed and embroidered, right and left hand, and formerly rested on a lion. A band crosses the breast and sustains the mantle, but there is otherwise no jewelry, and the neck is bare. All the small bronze figures and shields on the north side of the tomb have been removed, but on the south side the six figures, about 15 inches high, remain. They are indifferently executed, and represent four sons and two daughters of the king. Four small and beautifully enameled shields remain, showing that the red, which apparently cannot now be produced, presented no difficulty then. There are four large shields below, also enameled, two with the arms of England and two with red cross on a gold field.

In St. Edmund's Chapel we have a monument of great value, for it is, with one exception, the only existing specimen of the beautiful enameled tombs of Limoges; the other being now in the Louvre. The effigy represents William de Vallance, Earl of Pembroke, half brother to Henry III., and is a work of art formed of copper plates beaten over a core of oak. The body is in gilded chain mail and surcoat; the face, calm and handsome, if inexpressive, looks from a mailed hood with a jeweled fillet. The shield, belt, slab, cushion, etc., are richly enameled, and the tomb must, when complete with its enameled sides and gilded figures and shields, have been a most gorgeous object. The earl died at Bayonne in 1296, so that the effigy is almost contemporaneous with that of Queen Eleanor. A similar tomb to Sir Walter de Merton, at Rochester, cost £41 5s. 6d., but has long since disappeared.

Of the same date almost as the monument of Edward III. is a bronze of absorbing interest, the effigy of the Black Prince at Canterbury. Unlike the regal effigies of Westminster, the warrior prince is represented in a complete suit of gilded mail and plate armor, with short heraldic surcoat; all armed in steel for battle, as directed in his will. The figure is splendidly modeled and cast, and full of dignity and repose. The head is enveloped in the *camail*, with long mustache and beard tucked in, and it is pillowed on the fighting helmet, surmounted by a gigantic lion crest, an original of which, as well as of the gauntlets on the hands, is suspended above. The head wears the pointed bassinet, with an encircling jeweled crown, which, like the large roweled spurs, the sword girdle, etc., is richly enameled. The body reposes on a metal table with deep chamfered edges to receive the inscription, and on the sides of the tomb are finely enameled shields. The whole is in most perfect preservation, and we are most fortunate indeed in being able to look on the actual personation of this splendidly historical figure, armed no doubt as he actually was on the memorable occasions of Cressy and Poictiers. He died in 1376.

Another sumptuous gilded bronze effigy of a warrior in full armor is that of Richard Beauchamp, Earl of Warwick, Governor of the Kingdom of France and Duchy of Normandy under Henry VI., in the Beauchamp Chapel at Warwick. He died 1439. The head wears a coronet, but no helmet, and like that of the Black Prince, rests upon the great crested *heaume*. The fashion of armor had completely changed in this interval, and we see chain mail discarded. The feet rest against a sitting bear and griffin: the figure is loose, and as beautifully finished underneath as above. The most salient and ornamental feature of the tomb is the permanent brass herse which protects it; for these are generally temporary structures set over the coffin while it lay in state, to receive the pall and hold the indispensable wax lights. There are gilt images of mourners and angels, as well as enameled shields, on the sides, and though not beyond criticism as a work of art, the tomb is most magnificent, and the metal work is as perfect as on the day of its erection.

The massive gates which close in Henry VII.'s chapel are the only examples of this application of bronze in the country in olden times. They are formed of massive plates of cast and gilt metal fastened to an oak frame. The design is paneled, the centers containing the oft repeated royal badges of Henry VII. and his predecessor in open cast work. The plates are bolted to the wood by rivets, the heads of which form smaller badges, such as knots and dragons, with larger roses at the intersections. The center gates measure about 8 ft. over, and have sixty-two panels. The side gates repeat the same design on a smaller scale. The lock plates are very beautiful, and have been engraved, but the center and two of the side ones are missing. Bronze gates or doors were favorite works in Italy, and enormous sums were lavished on them.

The screen round the tomb of Henry VII. is of great magnificence, and though massive and rich in the extreme, it does not look clumsy. At each angle there is a large octagonal open work column filled in with diapering, and there are in all thirty-two niches for saints, all but six of which have been stolen. The sides are divided into two tiers of traceried panels, divided by an inscription horizontally, and vertically by slender open work buttresses. The portcullis and the dragon and greyhound occur in the panels. There is an overhanging frieze, arched and groined beneath, of quartrefoils with roses and the portcullis, and above this again there was a handsome open work coping, nearly all of which has disappeared, together with a good deal of work from the inside. The doors, surmounted by the royal shield and supporters, are further emphasized by a projecting bracket supporting the crown of England resting on an upturned Tudor rose.

These remind one of Italian cressets, and doubtless held a light of some kind. The drawing exhibited is from a large and beautiful engraving by Hollar, belonging to my father, unique I believe, which shows the grille in its perfect state. The pilfering of so much of the metal work from the abbey tombs that was at all portable was not the result of fanaticism, but of simple theft carried on with impunity down to our own times.

There is a very handsome but rather heavy-looking bronze railing round the tomb of the Earl of Worcester in St. George's Chapel (1526), Windsor, which replaces the old one, plundered in the civil wars. I know of nothing similar in England.

So far, the metal work described, except the Limoges tomb, has been of English make. The tomb of Henry VII. and his queen, inside the grille, is the work of an Italian, Torregiano, who having broken Michael Angelo's nose with his fist, found it expedient to accept an invitation to work for those "brutes of English," as he subsequently described us to Cellini, his friend. It is inconvenient to study the effigies through the grille, and it is a pity that casts are not in the Kensington Museum, for they are splendid specimens of Italian renaissance art. There is a sublime simplicity about the figures of the king and queen, who are enveloped from head to foot in a plain mantle, without jewelry of any sort, and with the hands raised in prayer. The venerable and rather emaciated features of the king appear below a head-dress something like a modern traveling cap, with ear flaps, and a simple hood forms the head-dress of the queen. The faces are exquisitely modeled, and must be truthful portraits. The black and white marble is almost concealed by the rich metal decorations, the chief features of which are large medallions, each containing two patron saints, in high relief, with rich pilasters between. Angels sit at the corners, but in spite of the protective grille, the emblems they held, and even two of the wings, and the coronets of the king and queen, have been stolen.

The tomb of the venerable Margaret Beaufort, mother of Henry VII., is also the work of Torregiano, and equally beautiful as a work of art. The hooded effigy is in the attitude of prayer, and exhibits a face of much goodness and dignity. The drapery of all the older effigies has been modeled as if the figures were upstanding, but here the folds are natural to the recumbent position. The pillows on which the head rests are superbly worked, and above it is a peculiarly flat, open work canopy, while alongside the body are open buttresses. The rest of the tomb is in black marble, except the gilt shields in the centers of the panels and the inscription which borders the edge of the slab.

Torregiano was also commissioned by Wolsey to make a sumptuous monument, and it appears that 4,250 ducats had been expended, besides £300 for gilding, when his disgrace ended the work. The black marble sarcophagus is in St. Paul's, and contains the body of Nelson. Poor Torregiano went to Spain, and was burned by the Inquisition for smashing a figure of the Virgin which was insufficiently paid. At this moment we appear to have been very near to establishing a bronze industry in England, when the services of Cellini and others would probably have been secured to us instead of to France, but the Reformation completely upset all hope of this, and drove away the foreign artists that had already been attracted. Again, under Charles I., there was a great possibility of our becoming an art country, on a level with Continental nations, but the scarcely risen sun of art was once more drowned in a sea of religious and political strife, and so effectually, indeed, that it has only now begun to peep up again.

There are but two more bronze tombs to mention in the abbey, both of them in Henry VII.'s chapel, both ambitious, but just missing the sublime. They illustrate the strong feeling for art which was growing up under the influence of Charles I.

The tomb of Villiers, assassinated by Felton in 1628, is the more pretentious. The duke and duchess repose in state, the former in highly enriched plate armor and an ermine cloak and the latter in robes. The duke wears his orders, and both are coroneted. A vast number of figures emblematic of the duke's fame and virtues surround them. At the feet is a figure of Fame blowing a trumpet. By their sides, plunged in grief, are life size bronzes of Mars, Neptune, Pallas, and Benevolence. Above are several figures in white marble, and some gilt bronze decorations. At the angles are black marble obelisks, once decorated with gilt metal, and still resting on gilt skulls. The bronze work of the tomb is very good, and without the lofty and over-enriched back and the figure of Fame it would have been admirable.

The second monument is to the Duke and Duchess of Richmond and Lennox, who died 1624. In the center is a handsome sarcophagus of black marble. At each angle is a fine figure of Faith, Hope, Charity, and Prudence, performing the office of caryatides, and supporting a baldachino, consisting of marble entablature, and pierced bronzed dome-shaped canopy, surmounted by Fame. On the sarcophagus are the effigies of the duke and duchess clasping hands, and richly attired. The duke is in magnificent embossed plate armor, mantle, collar of the garter, ruff, and coronet. The entire monument is sumptuous, very suggestive, and, except the figure of Fame, is a fine work of art. It shows that the canopied form of tomb in metal has very great capabilities, particularly in the open.

We now come to the flat incised metal monuments known as brasses. I have scarcely felt competent to deal with these, and my friend, Mr. F. A. Walters, F.S.A., has kindly helped me out of the difficulty, and to his accomplished pen the following all too brief account of them is due. To him and to Mr. John Codd we are indebted for the fine display of rubbings which admirably illustrate our subject:

"A most interesting branch of artistic metal industry, during the middle ages and later, was the engraving of memorials to the dead on sheets of the metal now known as brass, but then termed 'latten.' This metal, known in ancient times as oricalchum, was composed of calamine (carbonate of zinc) calcined and mixed with less than two-thirds of its weight of bean shot copper, melted in crucibles. The earliest record of its manufacture in England occurs in sundry patents granted for the purpose by Queen Elizabeth in 1565 to some Germans. Previous to this time it was imported into this country from Flanders and Germany, under the name of 'cullen plate,' from Cologne, the chief place of its manufacture.

"The earlier monuments of brass, first found in the twelfth century, are in low relief, and with those engraved and enameled, after the manner of the well known work of Limoges, formed the connecting link between the arts of the sculptor and enameler and that of the later engraver.

"Engraved memorial brasses probably originated in Germany, and the earliest existing example now to be found is at Verden, in Hanover, dated 1231. There are, however, recorded examples of earlier date, even in England, one as early as 1208 being said to have existed at Bedford. At present we have no specimen older than 1277, the date of the fine brass of Sir John d'Abernoun, in the church of Stoke d'Abernoun, Surrey. After this period we find these memorials in ever increasing numbers, down to the early part of the sixteenth century, when they became less frequent, and ceased altogether about the time of Charles I.

"Although the sheets of metal came from abroad, brasses appear to have been much more largely employed here than on the Continent, for, notwithstanding the wholesale destruction during the troubled times of the sixteenth and seventeenth centuries, and their neglect since, we have still over 4,000 known examples remaining. Over the whole Continent of Europe their number is said not to exceed 200 at the present time, although, as with us, they were formerly much more numerous, very many having been lost or destroyed, especially during the French revolutionary period. The brasses in England are evidently the work of native artists, their characteristics being quite distinct from those on the Continent. The few fine examples that we possess of brasses of foreign make serve to bring this out very clearly.

"The special distinction of English brasses is that the figures, canopies, and other parts of the design were all cut out of the sheets of metal, and let into slabs of hard stone or marble, which then formed their background, leaving the design clear and distinct in all its parts. The foreign examples, on the contrary, have the whole design engraved on rectangular sheets of metal, every portion of which is covered, the backgrounds to the figures usually having richly engraved

diaper work in lieu of the plain stone surface of our own specimens.

"The latter part of the fourteenth century saw the rise of a splendid school of Continental brass engravers, probably Flemish, whose works, many evidently by the same hands, are now to be found scattered over the whole of northern Europe. The noble brass of Abbot Delamere at St. Alban's—one of the few foreign brasses in England—is a typical example of this school, being in many of its details identical with those of about the same date at Lubeck, Schwerin, and Stralsund, in North Germany, and Thorn in Prussian Poland, showing how widely extended was their reputation.

"In England, toward the close of the fifteenth century, the art displayed on monumental brasses began to decline in a marked degree, many after this period being of very rude execution. This does not appear to be the case with the Flemish and German examples. The Flemish brass of Andrew Eryngar (1536), merchant of London and Antwerp, in the church of All Hallows, Barking, is decidedly superior to most English brasses of the same date, while the magnificent brass, dated 1510, in the Cathedral of Cracow is not surpassed, if equaled, as regards the figure, by any earlier example.

FIG 1.—FIGURES FROM TOMB OF DE LANNOY.

"Before concluding, it may be remarked how suitable is this kind of memorial in churches of the present day, especially if made mural, as has been done with most of the Continental brasses. They occupy no space, they may form pleasing and appropriate decorative features, and their cost can be very moderate, while they remain totally uninjured by the hand of time, thus forming the most lasting of all monuments. Those that remain to us from previous years are most valuable records in matters of history, costume, and heraldry; while in recent years the claim to an ancient peerage was established on the evidence furnished by a monumental brass of the 15th century." So far Mr. Walters writes.

France was probably much richer in metal tombs than England, for Limoges was from the earliest times a seat of manufacture, and the art has never ceased to be encouraged from the time when Cellini was invited to take up his abode in Paris till the present day. The revolution swept away these memories of the past by wholesale, for works in bronze were early sought to melt into money or cannon, of which the French soon stood in sore need.

Mr. Birch has described the Limoges bronze of Blanche de Champagne, 1283, in the Louvre, the only specimen of the art, except our own, of De Valence, which has escaped destruction; and also the two bronze bishops of Amiens, each supported on six lions, 1220–37, earlier in date than any bronze monument in England. With the outbreak of the revolution, a descriptive account was fortunately commenced of the monumental antiquities of France ("Antiquites Nationales ou

FIG. 2.—SIDE VIEW OF THE TOMB OF DE LANNOY.

Recueil de Monumens," by Millin), which conveys some idea of what was destroyed. In the Collegiate Church of St. Pierre, at Lille, some of great interest stood. That of Hugues de Lannoy and his dame, 1456, recalls the Warwick tomb, showing a similarly armed knight, bareheaded, and without gauntlets, and with surcoat embroidered with the arms of Flanders. The artist has given both a severe expression. A still more sumptuous tomb was that of Louis de Masle, Count of Flanders, who succeeded his father in 1346, almost immediately after the battle of Cressy, where he was wounded. He was forced by his subjects of Ghent to affiance himself to Isabel of England, but escaped and married Marguerite of Brabant, whose effigy, with that of their daughter, Duchess of Burgundy, reposed beside his own. During one of the desperate *emeutes* at Ghent he barely escaped by hiding himself in the children's bed of a poor woman's cabin; and after a stormy reign he died before the expiration of a year's truce, imposed on him by the English. The monument was erected by the Duke of Burgundy in 1455, and represents the count in rich armor, except the hands and feet, while the head wears a hat with upturned brim and jeweled front. The face is full of character, with fine expression, short pointed beard, mustache, and wavy hair. Sword and *misericorde* are worn, and on shield and breast are the lion of Flanders. The ladies are chiefly remarkable for their *coiffures* and many-buttoned sleeves. Two angels with wings extended high kneel at the head, and between them is the great *heaume*, surmounted by a crown and crest. Round the tomb are twenty-four figures of princes and princesses of Flanders and Burgundy, which are most exquisitely modeled, and an epitome of the costume of the nobles of the period. The whole was ruthlessly consigned to the melting pot, in spite of its interest and beauty.

The Westminster Abbey of France was St. Denis, which must once have far surpassed our own places of royal sepulture in the number of its bronzes. We may instance the famous tomb of Charles le Chauve, of the 12th century, the great doors of the cathedral, and the mausoleum of Barbazan, 1432.

But perhaps as rich was the church of the Celestins, now destroyed. Successive kings emulated each other in their gifts and endowments, and it contained a vast number of celebrated monuments. We will only stop to notice some of those which were receptacles of hearts, and not of the entire bodies of the dead. It was the practice, as we have seen in the case of Queen Eleanor, to bury the heart separately, but we have very few of the monuments left in this country which contained them. In the southern chapel of Henry the Seventh's Chapel is an obelisk of black marble, surmounted by an urn, containing the heart of Esme Stuart, 1611. They generally took a pyramidal form, and some were of great beauty, and might well serve as models in cases of cremation. One of the finest was fortunately secured, and deposited in the Louvre. The pedestal is ornamented with acanthus leaves, lions' paws, rams' heads, and Cupids, and on it stand three draped graces, considered the *chef d'œuvre* of Germain Pilon. A bronze urn is supported between them, which contained the hearts of Henri II., the Duc d'Anjou, and Charles IX. of evil memory. The monument was made for Catherine de Medicis, and we fortunately possess a cast of it in the Kensington Museum. In the same Orleans Chapel of the Celestins stood a white marble column, with three children holding torches at its base on a porphyry stand. On the summit is a bronze urn, upon which a graceful Cupid is in the act of placing a crown. It contains the heart of Francois II., who died in 1560, at the age of seventeen, after a reign of only seventeen months. Another splendid tomb, of the same class (by Barthelemi Prieur), contains the heart of the great Anne de Montmorenci, created Constable of France in 1538. The column is twisted and ornamented with foliage and flutings, with composite capital and bronze urn. The pedestal is of marble, accompanied by three bronze statues of the virtues bearing insignia. Montmorenci was illiterate and avaricious, and seems always to have been beaten or taken prisoner in his battles. He behaved with great brutality in entering Bordeaux, though the town was surrendered, hanging one person for every ten houses. On another occasion he committed an action like that which covered Colonel Kirk with infamy. He was killed at the battle of St. Denis by a Stuart, and buried with regal pomp. Another monument in the same church, to Timoleon de Cosse, is of somewhat similar character.

Flanders was also rich in sepulchral bronzes. We can only notice the celebrated tomb of Mary of Burgundy, wife of Maximilian, constructed 1495–1501, and the slightly inferior but very similar tomb of her father Charles the Bold of Burgundy, which was not executed till 1558. The tombs are black marble sarcophagi, on which repose the life sized effigies in gilt bronze, the tomb of the empress being by far the finer of the two, and was formerly covered by a herse of forged iron, designed by the painter Jean d'Hervy. The richest

FIG. 3.—TOMB OF LOUIS DE MASLE, COUNT OF FLANDERS.

heiress in Europe, the sides of the tomb are filled with enameled shields with the arms of the duchies, counties, and estates which she brought to the house of Austria. Pierre de Beckere became paralyzed, and lost many workmen, from the effect of the mercury in gilding this tomb. Her death was through a fall from her horse while hunting near Bruges. The tomb of the husband of this princess at Innsbruck (1583) is, without any question, the most sumptuous monument of bronze in the world. The figure of the emperor, crowned and in his robes, is kneeling on a lofty marble pedestal, at the angles of which are superbly modeled female figures. Beneath are the celebrated white marble panels, representing events in the life of Maximilian, and around is a most elaborate grille of the type peculiar to Germany in the 16th century. Round this magnificent tomb stand twenty-eight figures of heroic size in massive dark bronze. They comprise, besides members of the Hapsburg family, a number of historical personages, among them King Arthur, Theodoric, and Godfrey de Bouillon.

Many of the figures are by Vischer, of Nuremberg, and it is said that they were seventy years in hand. The costumes are of the highest interest, and while the pose

FIG. 4.—BRONZE URNS FROM THE CHAPEL OF THE CELESTINS.

of many of these kings and warriors, with their dames of high degree, is not without grace, the majority of them are in a sturdy attitude befitting powerful Teutons. In a side chapel are twenty-three statuettes, cast at Augsburg by Geoffrey Loffler, 1508, destined apparently for a bronze grille never carried out. The large figures have a startling and most awe-inspiring effect, especially if seen for the first time by a waning light.

The second most celebrated tomb of bronze in Germany is undoubtedly that of Saint Sebaldus, in Nuremberg. Of totally different style, it is impossible to convey any adequate description of it in words, but its general form is a richly canopied shrine, with figures of the twelve apostles on the supports, and innumerable smaller figures and enrichments wherever there is room to place them. Though of Gothic outline, there is fine Renaissance feeling in the detail, as might be anticipated in the *chef d'œuvre* of Peter Vischer. The shrine itself is a chest of silver and gilt *repousse* work, checkered all over with the imperial arms, and its pedestal is paneled in bass-reliefs representing the life of the saint. The whole, canopy and all, rests on a bronze slab supported on snails, which appear to be slowly and irresistibly bearing it forward. Noticeable features are the mermaids, holding sconces at the angles, and the figure of the artist at one end. It weighs eight tons, and was made 1508 to 1519, and a cast of it is in the Kensington Museum. Germany abounds in bronze tombs, and we possess casts of those of Canon de Veltheim, Hildesheim, 16th century; Lucas Cranach, Weimar, 16th century; Presbyter

Bund, Hildesheim, 13th century; Otto IV. by Vischer, Thuringia; Count and Countess Weinnberg, Munich; Count Hennenburg, etc. Other fine bronze tombs are at Aschaffenburg, Wittenburg, Magdeburg, Cologne, Coburg, Cassel, Bamberg, etc. In Germany there are also bronze tombs in low relief, a type unknown elsewhere, numerous examples of which occur at Bamberg, Marburg, Breslau, etc. These pass almost insensibly into brasses, which occasionally have the features raised in relief.

We must, unfortunately, for want of time, wholly pass over the bronze tombs of Italy, though many popes are commemorated in bronze in St. Peter's, and tombs of the finest character abound everywhere in that country. There are also a few in Spain, like that of Juan II. at Burgos.

The various methods of producing these works of bronze and brass is by no means the least interesting section of the subject. One, very often practiced in antiquity, was to beat metal plates over a core of wood or other material, and rivet or solder them together. We have seen an example of this work in the De Valence tomb. The last time it was practiced in Europe was probably in the Carlo Borommeo statue at Arona. Objects in the Chinese Court at Kensington show both methods. This was succeeded by casting figures piecemeal, and burning the pieces together, all Greek cast statues being produced more or less in this way. Lastly, figures were cast at once, *d'un seul jet*. Originally, perhaps, and certainly during the Renaissance, the *cire perdue* process was adopted. This was so fully described by Mr. Simonds in the *Journal* for February 5, 1886, that it is quite needless to recapitulate it. The process is delicate, long, and risky for large objects, and the original is every time destroyed, so that piece moulding in sand is preferred commercially. It is entirely erroneous to suppose that the art has ever been lost, for the group of gladiators by Gerome, so much admired in the Trocadero, was produced by it. A full and most interesting account is preserved of the casting of the great equestrian statue of Louis XIV. by it in one jet. Piece moulding in loamy sand leaves certain seams, which necessitate chasing the casting to a greater or less extent. Artists differ as to whether bronze should be chased. My own opinion is that a mere *fac-simile* in bronze of the wax is opposed to the nature of the metal, and looks plastic as gutta percha. In France the art of chasing has arrived at such perfection that the artist can safely intrust his work to professional hands, feeling sure that the surface will merely be caressed and smoothed from roughness and imperfections. Natural objects can be pressed into sand, calcined, and the ashes blown out. Barbedienne, in Paris, produced sprays of leaves, crayfish, etc., in this manner, and the Japanese appear to resort to it. I have one or two small fish left that I had cast some years since. The small object kindly exhibited by my friend Mr. Purdon Clarke has been described by him to the Iron and Steel Institute. In the larger half of the gourd-shaped object is a bronze chain pattern bracelet, just as cast. The links were modeled in wax, which was covered by thin coatings of red clay, until at last a thick coating, such as you see, is produced. The smaller chamber of the gourd is filled with metal, and placed in a primitive furnace. The wax melts, and escapes through a small vent, and after a time the metal, too, melts, and takes the place of the wax. This is the *cire perdue* process in its simplest form. Messrs. Elkington have produced statuettes, and even small statues, by electrotyping.

The hasty and imperfect glimpse we have taken of some existing bronze tombs by no means conveys an adequate idea of the capabilities of the material for even this purpose alone. In the cemetery of St. John, Nuremberg, some 3,000 gravestones of bronze have been placed, from the 15th century down to the present day, the oldest of which are indistinguishable, as to color and preservation, from the new. A cast of that to Albert Durer is at Kensington. The fine modeling of the arms and mantles, and the rich coloring of the bronze, produce an impressive effect, and whether we take a cursory survey, or linger to decipher and study, the feeling of reverence abides. Above all, the display of weakness and variety—that string so successfully played on by the undertaker—is nowhere discernible. In our cemeteries we are somehow made to feel that Smith was richer than Jones. They are cities without plan, buildings without architects—a vast aggregation of tasteless, stock pattern monuments, scuring down on each other on every side, until the whole expanse becomes a forest of broken columns, urns, and obelisks—a wilderness paved with stones, on which vast sums have been uselessly sunk. Fortunately, our urban and suburban cemeteries have but an ephemeral existence, and the ponderous slabs which we have piled on the dead as if there were to be no "Resurrection of the body," are spirited away, and give place to flowers and shrubs. If the exact burial spots had been simply marked, and the stones to perpetuate the memory of the dead contributed on some fixed plan, what splendid and lasting mortuary piles might have been raised, eclipsing the *Campo santos* and colonnaded cemeteries of Italy.

It is difficult to believe, however, that our respect and affection for the dead is not more fittingly expressed by the erection of some memorial of use to mankind, and I fear it is too often overlooked that a monument is not necessarily a building, statue, or tombstone. Anything by which the memory of a person or an event is perpetuated is a monument, and not the least beautiful and appropriate of those that have been handed down are windows, screens, and fonts. Pure objects of art, especially if they recall the memory of noble qualities, exert an undefinable influence for good on mankind, and the wisdom that guides our gracious Queen is better exemplified in nothing than in the magnificent patronage she has afforded the sculptor's art in commemorating her lamented consort. The sculptor's art, indeed, lives but to commemorate the past, but there are persons of average wealth daily desiring to record the losses that death occasions every hour, to whom the price of sculpture is prohibitory. If we could but divert this perpetual golden shower from the undertaker's catalogue, the art of the metal worker would need no other patronage, for works in bronze and brass, from their imperishable nature, must ever satisfy this sentiment in the highest degree. The trumpery fittings of our churches would soon be replaced by lecterns, fonts, rails, standards, and coronæ, for even a simple bracket could be made most amply to satisfy the mind, if art predominated in it. Such memorials need be neither elaborate nor costly, but each one must be designed for its purpose and the position it is to occupy, for the sentiment and the encouragement to art at once disappear if they are chosen from catalogues of stereotyped forms. In all cases obtain, in the first place, the advice of an architect or artist.

Even more ambitious forms of monument for our public places are within the reach of many if they did but know it. I could give an instance where a thoroughly satisfactory work of art is now erecting at a cost less than I have known to be paid for a simple brick and granite grave. We are really not limited to statues, a commission for which seems to paralyze the art in even our best sculptors. Our great ones may tower head and shoulders above their fellows in worth and intellect, but in feature and physique, especially when clad in coat and trousers, they cut a poor figure in bronze, and it is plain the artist models them for money, and not love. The diploma groups in bronze belonging to the Royal Academy show of what our English sculptors would be capable if allowed to commemorate people's deeds ideally. Unlike the French, we erect little to the heroes of the past. The appearance of Drake, Frobisher, Raleigh, and hosts of other grand figures in history are unknown to us by any monuments. We have no representation of the most graceful animal, the horse, apart from its rider; nor of the dog, though it save our life or win us thousands; nor the bull, the incarnation of force and courage; nor the eagle, stork, nor of any one of God's creatures, be it never so admirable. Yet we admire the horses of St. Mark's, the Marly horses, the Farnese bull and boar, the storks and eagles of Japan.

Reproductions from the antique could be set up in bronze in our parks or gardens for little more than £100, and original vases, fountains, lamp-posts, for £100 or £200. The parks and gardens of France, such as the Tuileries, Marly, Versailles, St. Cloud, abound in vases, statues, and groups. A thick volume is required to illustrate the fountains of the streets of Paris alone. The magnificent bronze column of July, over 150 feet high, and weighing 179,500 kilogrammes, or the scarcely less lofty bronze column of the Place Vendome, with its 260 meters of bass-relief, are wholly unrivaled monuments. Ever since the days of Cellini and Primaticcio, the most lavish patronage has been bestowed on the artist in bronze in France. The splendid gilt bronzes of Versailles were produced by the state at the Gobelins; the bronzes for the Tuileries, etc., were produced at the state *Fonderies de l'Arsenal;* and works in bronze, costing many thousands, are still produced at the state porcelain factory of Sevres. As a result, the bronze industry of France has amounted to 80,000,000 francs yearly, of which a million sterling was for export. Every French bourgeois home possessed its elegant *garniture de cheminee*, its lamps, and girandoles, in good taste, its bronzes, or no less artistic *zinc d'art* of home manufacture, its waxed oak floor and Persian rugs, while we wallowed in the hideous Birmingham "gasalier," staring wall papers, and vulgar carpets. We are only now taking a place in matters of art manufacture among nations, but when will one of our manufacturers be rewarded with a commission like that of £10,000 for a clock for the Hotel de Ville, or for the gigantic candelabra and lusters for the Opera; for the bronzes which furnish the Hermitage, Kremlin, and cathedral of St. Isaac, in Russia, or the damascened tomb, by Zoloaga, for General Prim, in Spain? We in England push our way without state aid, and such works of art as our government do require from manufacturers is made rather a matter of lowest price than an encouragement to the deserving. Nevertheless, with a little more public appreciation, our metal workers will not perhaps be found altogether lagging in the race; while our schools of art are certainly furnishing us with such a body of artists that the manufacturer will have little excuse for sticking in the old ruts.

VISCERAL DISORDER AND MENTAL DISEASE.

IN the *Brit. Med. Jour.*, Dr. James Adam contributes a case of mental disorder due to the accumulation of feces in the lower bowel. The patient was a lady, aged 50, who had always enjoyed good health until about three weeks before she came under the author's care. There were great melancholy and mental depression, determined obstinacy, constant restlessness, tossing about and tearing her hair, walking abroad in her night dress. She was so violent that it was impossible to keep her in one position for a moment, and she had not slept for several nights. When seen by Dr. Adam, she was profoundly taciturn, and refused to take nourishment in any form. There was a history of constipation, and consequently she was given aperient medicines and enemata. She was fed three times a day by means of the stomach pump. At the end of a week she was no better, and no action of the bowels had taken place. On examining the rectum, a large hard dense mass of scybala was found; this was broken up, and large enemata were given, so that the lower bowel was thoroughly evacuated. Very soon after free evacuation of the bowels, all the worst symptoms began gradually to disappear, and three weeks later the patient was calm, coherent, and industrious, and quite restored to her natural health.

PASCAL'S VASE.

To the Editor of the Scientific American:

In your issue of February 4 you illustrated Pascal's vase. I want to thank you for publishing such an elegant and simple method of illustrating the pressure of a column of water. I often felt the need of this to instruct apprentices, also journeymen much older than myself, who do not understand this law. I constructed one by the aid of your instructions, and for the aid of any one who might want to do likewise, I will give this information. I secured an ordinary fruit jar, known as the lightning jar (it has a glass cover). I cut off the bottom with a hot poker, removed the wire fastenings, bored 2¾" hole through an inch board, forced the glass cover into the hole, so the under side of cover was flush with face of board. I then nailed the board down on the work bench. This allowed enough wood above the cover to form a guide for the neck of the jar. I now have the *top* of the cover exposed through the hole, which has a better surface than the under side. Also the under side has a better face for the pin, as it is concave, while the top is convex. The top of jar is ground nearly true. Select one that has no nicks in, place sand and turpentine on cover, insert neck of jar and revolve it steadily, and you will soon have a perfect fit, and a plate that will not be broken very easily. The rest of work was done according to your illustration.

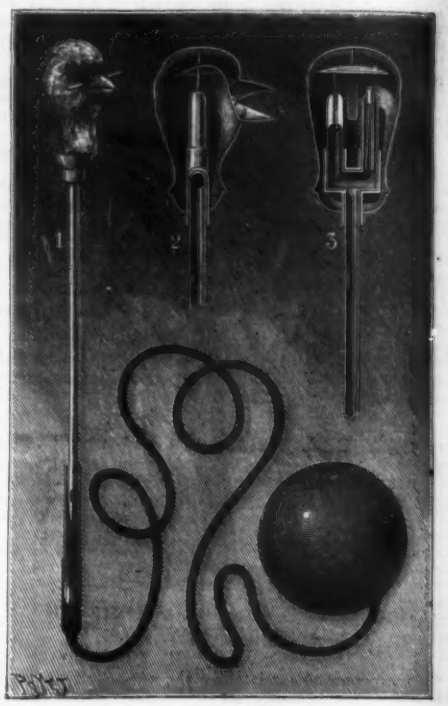
D. H. STREEPER.

Norristown, Pa., February 6, 1888.

CURIOUS CONTRIVANCES.

A SINGING SCARF PIN.

A SKILLFUL manufacturer has recently submitted to our examination an animated piece of jewelry which is a marvel of ingenuity. It is a scarf pin bearing a

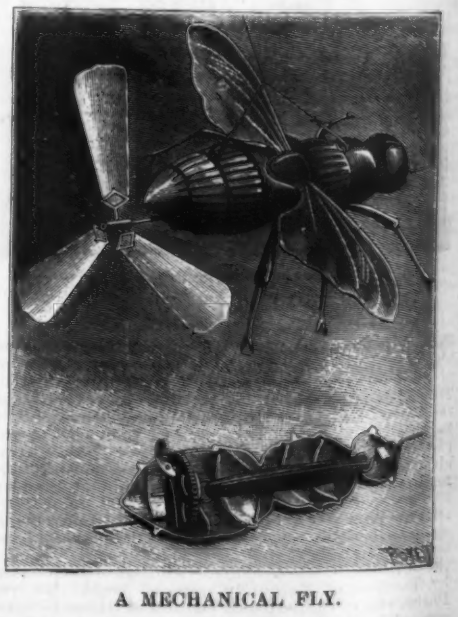


SINGING SCARF PIN.

bird's head. You ask some one to examine the pin, and, at the same moment, the bird's beak opens and emits a very expressive twittering sound. Our engraving represents this object with the mechanism that actuates it. The pin is stuck into the scarf, which must be a long one, and its point is made to enter a sheath to which is attached a rubber tube that is concealed behind the vest. This tube, which is about two feet in length, terminates in a rubber bulb which is kept concealed in the trousers pocket. On pressing the bulb with the hand, air is forced into the tube, and this actuates the mechanism contained in the head. The sections that we give show the arrangement of the mechanism, which is formed of a U-shaped tube. The air, in passing into one of the branches of the latter, circulates through a little whistle, and in the other branch raises a small piston provided with a counterpoise that opens the bird's beak. The maker of this pretty little device calls it the "autopneumatic singing pin." When it is desired to use the pin as an ordinary ornament, the rubber tube is removed.

A MECHANICAL FLY.

As the holidays approach, manufacturers of toys begin to tax their ingenuity to devise new mechanisms



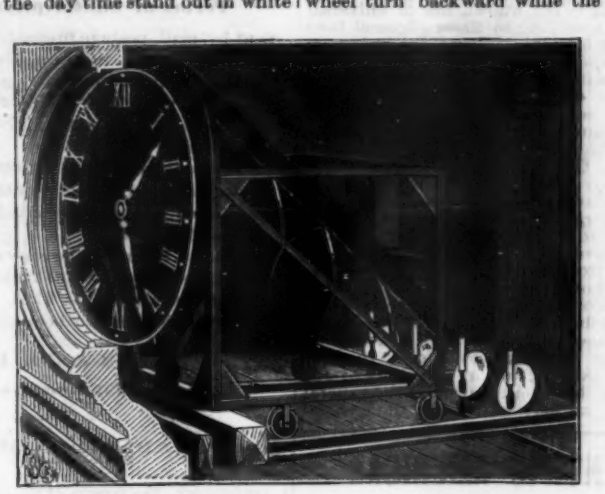
A MECHANICAL FLY.

or to give new forms to those already in use. The fly that we figure herewith is an ingenious arrangement of those spring motors that are so often employed in the mechanism of toys.

This fly, which is of varnished metal, is 5½ inches in length. It is to be suspended by a long string from a hook in the ceiling or from the lower part of a chandelier. In such a position it oscillates freely, like a pendulum. It contains, as shown in the section at the bottom of the engraving, a number of strips of rubber that are submitted to torsion through a small winch. The taut spring acts upon a gearing that sets in motion a three-bladed mica helix mounted in the rear. The freeing of a catch permits of setting the mechanism in motion at the moment desired. The helix, through its revolution, gives the fly a rapid motion, and makes it traverse a circle around its point of suspension. The diameter of the circle is so much the greater in proportion as the revolution of the helix is more rapid. The little apparatus is elegantly constructed and has a very pretty appearance.

CLOCK DIALS WITH LUMINOUS HANDS AND HOURS.

For many years there has been a clock in the yard of the Saint Lazare station at Paris in which the hands and hours in the day time stand out in white upon a black background, but at night appear translucent and luminous upon the same ground. A new clock of this kind has just been constructed in the new buildings of the Administration of the Railways of the West. This clock is placed on the side of the building facing the track, and was constructed by Mr. Paul Garnier.

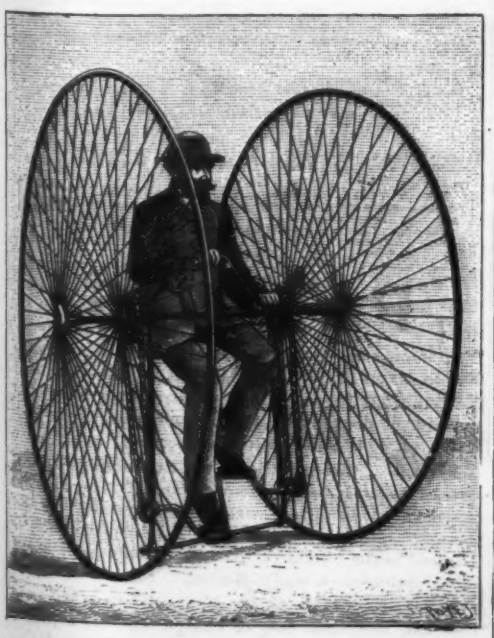


CLOCK WITH LUMINOUS HANDS AND FIGURES.

The system of lighting employed in clocks of this kind was devised forty years ago by Mr. Dovey, and is based upon the peculiar properties of black backgrounds. The dial is of white, transparent glass and the hands and figures are of opal glass. The whole is mounted in an aperture in a chamber hung with black cloth. During the day, the external aspect of the dial is black, and the hands and figures stand out in white upon it. When night comes, four burners are lighted that are provided with parabolic reflectors directed in such a way as to distribute the light as uniformly as possible over the dial. It is easy to see that when the burners are lighted, the white and translucent figures seen externally appear luminous, and the hands, which also are of opal glass and receive light through the transparent glass, take the same aspect, whatever be their position.

In order that the interior of the clock may not be seen from the outside, the dark chamber is formed of black cloth stretched over a frame as shown in the engraving. Thus from the outside, and even from neighboring houses, nothing can be seen through the transparent dial but the cloth that forms the black background. The axle of the hands is hidden by winding it spirally with black chenille.

To render the effect complete, the transparent dial must be kept free from dust, which would render it visible.



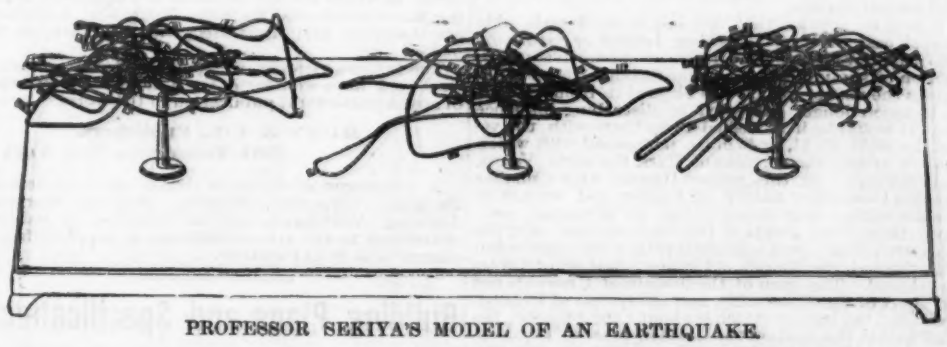
THE "WALTZER" BICYCLE.

THE "WALTZER" BICYCLE.

The wheels of this bicycle are each 6½ feet in diameter and are mounted at the extremity of the same axle, at a sufficient distance apart to allow a person to move freely between them. The seat is suspended from the center of the axle, beneath and a little behind it. A pedal arrangement, analogous to that of tricycles, is situated at the lower extremity of a vertical frame suspended from the axle. This device is provided at each extremity with a cog wheel that actuates the pitch chain that drives the wheels of the bicycle. It will be seen that if these two wheels were directly driven by the chains, the bicycle could move only in a straight line, and could not turn in curves, since the rotation requires that in this case one of the wheels shall run faster than the other. So the inventor has devised an arrangement of pinions and gearings moved by a small crank shaft which is held in the hand and permits of braking one of the wheels while the other is moving, or of slackening the speed of the one with respect to that of the other, or, finally, of making one wheel turn backward while the other is moving forward. In this latter case, if the two velocities are equal, the apparatus will wheel around, and the velocipedist will turn like a top, whence the name of "Waltzer" bicycle given to this machine by its amateur manufacturer. The advantages of stability and speed are largely offset by grave inconveniences. The principal of these is the difficulty of preventing the distortion of wheels of so great diameter; so we make this apparatus known only as a matter of curiosity.—*La Nature.*

A MODEL OF AN EARTHQUAKE.

IN the latest part of the journal of the Science College of the University of Tokio, Prof. Sekiya describes a very curious and remarkable model he has made to exhibit the manner in which a point on the earth's surface moves during an earthquake. Readers who have followed the recent progress of seismometry in Japan are aware that the motion which is recorded at an earthquake observatory is a prolonged series of twists and wriggles of the most complicated kind, so that the path pursued by a point on the surface of the soil has been aptly compared to the form taken by a long hank of string when loosely raveled together and thrown down in a confused heap. Prof. Sekiya has taken advantage of a very complete earthquake record obtained by him with a set of Prof. Ewing's seismographs to follow out this path step by step, and to represent it, in a permanent form, by means of stiff copper wire. The earthquake he has modeled in this way took place on January 15, 1887, and was unusually severe, for Japan. It has been already described in *Nature* (vol. xxxvi., p. 107), and we have given there a copy of the seismographic record, by help of which the model has been constructed. The seismogram shows the vertical displacement and two rectangular components of the horizontal displacement, instant by instant, throughout the disturbance.



PROFESSOR SEKIYA'S MODEL OF AN EARTHQUAKE.

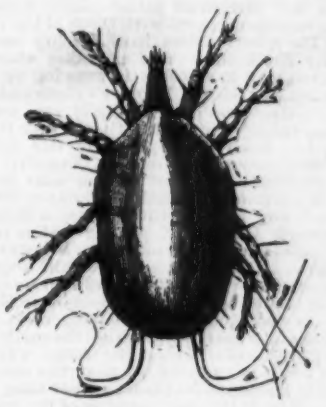
It was only necessary to go through the laborious task of compounding the three displacements in order to find the actual path. This Prof. Sekiya has done for the first seventy-two seconds of the earthquake—a period which embraces all the most interesting features, although large movements in a horizontal plane continued for a minute more, and small movements for a still longer time.

After the seventy-second second, however, the vertical component of motion had virtually disappeared, so that the latter part of the disturbance might be represented by a curve drawn on a horizontal plane. To avoid confusion, the model (a sketch of which is given above) is constructed in three parts: the first and second parts each refer to twenty seconds, the third to thirty-two seconds. The parts are mounted together on a lacquered stand 3 feet long, genuinely Japanese as to its legs, as the sketch will show. The model represents the absolute motion of the ground magnified fifty times. Little metal labels are attached to the wire to mark successive seconds of time, from 0, where the shock begins, to 72, where the model ends.

Prof. Sekiya is to be congratulated on his patience and skill. The model will serve to show at a glance the real character and enormous complexity of earthquake motion; it may also serve to open the eyes of seismologists of the older school to the perfection to which earthquake measurement has now been brought. We learn by a Japanese advertisement that a native firm (Seirensha & Co., Tokio) has undertaken to sell copies of Prof. Sekiya's model, lacquered stand and all, at a price so low that it should induce many private persons, not to speak of curators of museums and others officially interested in scientific novelties, to possess themselves of this pretty and instructive Japanese "curio."—*Nature.*

THE SUGAR INSECT.

THE *Acarus sacchari* is almost always contained in unrefined sugars, and the average number per pound has been estimated as upward of 100,000. Filtration through the bag filters removes the creatures along with other sedimentary matters. Its food consists chiefly of nitrogenous matter contained in the coarse sugar. The illustration shows the magnified form of the sugar mite. It is only seen as a very minute moving speck on the surface of a solution of raw sugar. These insects are the cause of the "grocer's" itch, from which those workmen who handle the raw sugar suffer.



THE DOMAINS OF THE PLANETS.

ASSUMING as I do that the sun's distance is 92,780,000 miles, which I consider probably far nearer the truth than Newcomb's ninety-two and one-third millions, I find that his mass amounts to 330,500 times the earth's, and that the velocity with which matter drawn to his surface from an indefinitely great distance would impinge vertically upon that surface is no less than 382·57 miles per second. It is hardly necessary to say that none of his dependent orbs compares with him in this respect. If a body were let fall upon Jupiter from an indefinitely great distance, being drawn to Jupiter's surface by that planet's sole attraction, the velocity of impact would be but 37·37 miles per second. In Saturn's case the velocity would be 22·58 miles per second; in Neptune's case, 13·72 miles; in the case of Uranus, 13·25 miles; in the earth's, 6·913 miles (this represents the velocity of seven miles per second with which Jules Verne's Columbiad had to shoot forth those venturesome travelers to the moon); in Venus' case the velocity of impact, always supposing each planet left alone to generate the greatest possible velocity, would be only 6·218 miles per second; in the case of Mars it would be 3·179 miles; in that of Mercury, 2·901; while lastly, our small companion planet, the moon, if left to do its best alone on matter approaching it from a very great distance, could not generate a greater velocity than 1·482 mile in each second of time—though this, by the way, is a considerable velocity, being about four times the velocity with which a cannon ball leaves the mouth of the best cannon men have yet been able to construct.

But no planet is able to exercise its control on an approaching orb in this undisturbed fashion. There is only indeed a comparatively limited region within which the rule of a planet is superior to that of all other bodies, even including the sun. Each planet has in this sense a special domain, the limits of which are determined by the consideration that whereas a body outside those limits is drawn more strongly toward the sun than toward the planet, within them the reverse holds; and though it may be but for a time that the planet exerts superior influence, the influence of the planet on a body so situate is greater than that of the sun or than the combined influence of the sun and all other bodies whatsoever.

The sun, however, is the only orb whose power in

diminishing the control of the several planets over surrounding space need be considered, all other influences being relatively insignificant. He affects the rule of planets in two distinct ways: First, by his direct power in drawing matter toward him more strongly than any planet can, unless the body is comparatively close to its surface; and secondly, by communicating such velocities to bodies moving within the solar system that even when they enter the domain of a planet they remain within it but a short time. Since his power in both respects depends on his distance, or rather on the planet's distance from him, we find the outer planets set in a relatively higher position as independent rulers than the mere superiority of their mass would imply; nay, the outermost of the outer family is set absolutely higher in regard both to extent of domain and influence within such domain than even the two chief planets Jupiter and Saturn themselves.

I have calculated the extent of the domains of the several planets, and the velocities with which matter entering those domains would pass through them independently of the action to which they are exposed during their passage. The results are, I think, interesting, presenting, as they do, the relative sway of the different members of the solar system in a somewhat new light.

All the four terrestrial planets have domains very limited in extent compared with those of the four outer planets. The spherical domain of Mercury has a diameter of only 32,000 miles; and as bodies which chance to pass through it have velocities ranging up to no less than 42 miles per second, Mercury's chance of much influencing bodies passing near him is very small. Our own moon, though she has less than a fifth the mass of Mercury, has much more power in this respect, her domain being about 36,000 miles in diameter, while the greatest velocities of bodies passing near her are but 26 miles in a second. Venus has a domain 106,000 miles in diameter, and at her greater distance from the sun the maximum velocity of passing bodies is reduced from 42 miles per second noted in Mercury's case to only 30 miles. Our earth has a domain about 322,800 miles in diameter, and the maximum sun-imparted velocity of bodies entering that domain is 26 miles per second. As the span of the moon's orbit is nearly 478,000 miles, the moon is not within the earth's domain, nay, lies 77,500 miles beyond the range within which the earth's rule is supreme, so that the moon is to be regarded as a companion planet rather than as a mere satellite. Mars is the only member of the sun's special family of planets—for so I think we must consider the terrestrial planets to be—which has dependent bodies under its own special influence. For the domain of Mars is nearly 165,000 miles in diameter, while his satellites travel at distances of only 5,820 miles and 14,600 miles, respectively, from his center. At the distance of Mars the greatest velocities of passing bodies, so far at least as solar influence is concerned, amount to 21 miles per second, and Mars can do little to perturb bodies moving so quickly, even though their course should carry them through the very midst of his domain.

So soon, however, as we pass to the wide region within which lie the paths of the giant planets, we find planetary domains far wider in extent and wherein planetary influences are exerted under conditions much more favorable. The domain of Jupiter has a diameter of nearly 30,000,000 miles, within which the whole system of the Jovian satellites, the span of which is but 2,800,000 miles, is swayed by the planet's supreme influence, slightly modified by the sun's perturbing action, indeed, but only in the same sense in which the motion of the earth around the sun is modified by the perturbing action of Jupiter. The domain of Saturn is even larger, but so slightly that one may speak of the domains of Jupiter and Saturn as practically equal. (Their actual diameters are, respectively, 29,824,000 miles and 29,912,000 miles.) And though the Saturnian system of satellites has nearly twice the span of the Jovian system, the diameter of the orbit of his eighth satellite being no less than 4,500,000 miles, yet this system is as completely under Saturn's control as the motions of the terrestrial planets are under the control of the central sun. Matter which has entered within these two nearly equal domains travels with sun-imparted velocities ranging up to eleven and one-half miles per second in the case of Jupiter and to eight and one-half miles per second in the case of Saturn. Over matter so moving both Jupiter and Saturn may exert very considerable influence, modifying not only the direction of motion, but also—which is a point of much greater moment—its velocity, and so modifying the span and period of orbital motion which such matter may have had around the sun.

It is to be noticed that not only is the domain wide in each case within which either Jupiter or Saturn exerts superior influence, but the comparatively slow motion of sun-influenced matter through that domain causes the matter which has entered it from without to be much longer subjected to disturbing influence than it would be if it rushed along there with the velocities of 31, 26, 31, or 42 miles per second with which matter crosses the domains of Mars, the earth, Venus, and Mercury. In this respect Uranus, with a smaller domain than either Saturn or Jupiter, and weaker influence within that domain, has an advantage over both those chief giants of the solar system. For the greatest velocity (sun-imparted) with which matter can pass through the domain of Uranus falls short of 6 miles per second. The span of the domain of Uranus is not far short of 24,000,000 miles, and the system of Uranian satellites, the span of which is about 1,000,000 miles, lies well within the limits of the Uranian domain. But Neptune is, of all the members of the solar system, the one whose domain is widest, and whose influence within his domain is most strikingly paramount. This domain has a diameter of more than 40,000,000 miles, and in volume it is nearly equal to all the other planetary domains put together. Matter passes through this domain when entering it by chance from without under solar influence only, with velocities which range no higher than 4¾ miles per second; and as Neptune is so powerful that matter drawn to his surface under his own influence alone would have a velocity of impact amounting to 13¾ miles per second, it is evident that Neptune must be capable of perturbing the movements of such matter in very large degree.

Such are the relations of matter as we find it distributed within our solar system. A total quantity of matter surpassing even the tremendous mass of the earth no less than 331,000 times appears in this system aggregated into various discrete masses, nearly all, however, being at the center, whence it may not only influence, but warm and illuminate all the rest. We see the various masses, according to their amount and position, exercising sway over larger or smaller regions of space, and over more or less important subordinate systems. We note further the antecedent probability—and the evidence obtained by observation assures us of the actual fact—that the larger these several masses are, the more they retain of the heat due to the primary process of their aggregation, the more nearly do they resemble the chief mass in their power to warm—possibly in their power to illuminate also—the bodies circling around them.

If these details of our solar system were not, though I think they are, most interesting in themselves, they would be made supremely interesting by the consideration that each one of the stars tells us of an aggregation of matter resembling our solar system doubtless in origin, though the circumstances of their formation may have led to different details alike of distribution and condition. Here in our solar system certain processes acting according to the known law of universal gravitation, and also according to those physical laws on which the generation of the so-called physical forces depends, have led to the gathering together of an enormous central mass with the generation and steady emission of immense quantities of light and heat. Yonder in space we see in each star evidence of the steady emission of immense quantities of light and heat, assuring us of the past aggregation of immense quantities of matter. Our solar system is the one case we can actually study of the aggregation of matter under laws not yet clearly recognized, and still farther from being fully interpreted. It may perhaps be in one sense as hopeless to endeavor to guess how other such aggregations have been formed as it is to endeavor to ascertain from our earth's life history the life histories of her fellow worlds, or from the condition of our moon the state of all such orbs as have, like her, passed onward to the final stage of orb life, the condition of death. But even as from the laws of the life of any one animal we can form a general idea of the laws of the lives of other animals, and as the study of one plant affords data for the determination of the general laws of plant life, so we may fairly infer the general nature of the final stage of orb life from the condition of our moon, the general laws of world life from the life history of our earth (so far as we have been able to read it), and lastly the general nature of other sun-circling systems from the study of the distribution of matter within our solar system, and the state in which the matter so distributed exists, whether in the supreme central mass, in the larger or smaller among the subordinate masses, or in the relatively minute subdivisions of the original material of the system which we recognize in asteroids and satellites, in meteorites, aerolites, and finally in the particles of meteoric dust whose presence is attested by the phenomena of falling stars.—*R. A. Proctor, Knowledge.*

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